Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091720	2	1	1	200	29.9	32.41	0.02	12.55	2.62
RQ091720	2	2	1	200	28.0	32.41	0.02	13.14	2.45
RQ091720	2	3	1	200	28.8	32.41	0.02	13.34	2.66
RQ091720	2	1	2	200	29.9	32.41	3.86	24.48	4.68
RQ091720	2	2	2	200	28.0	32.41	3.86	24.32	4.64
RQ091720	2	3	2	200	28.8	32.41	3.86	23.03	4.48
RQ091720	2	1	3	200	29.9	32.41	36.78	29.62	4.63
RQ091720	2	2	3	200	28.0	32.41	36.78	33.22	4.75
RQ091720	2	3	3	200	28.8	32.41	36.78	28.36	4.61
RQ091721	1	1	1	200	34.1	2.40	0.97	90.18	9.29
RQ091721	1	2	1	200	32.9	2.40	0.97	82.85	8.70
RQ091721	1	3	1	200	32.9	2.40	0.97	88.03	8.64
RQ091721	1	1	2	200	34.1	2.40	4.81	87.99	7.51
RQ091721	1	2	2	200	32.9	2.40	4.81	80.73	7.02
RQ091721	1	3	2	200	32.9	2.40	4.81	87.56	7.03
RQ091721	1	1	3	200	34.1	2.40	33.89	85.89	7.92
RQ091721	1	2	3	200	32.9	2.40	34.00	92.49	8.52
RQ091721	1	3	3	200	32.9	2.40	34.00	90.32	7.94
RQ091721	2	1	1	200	33.9	32.26	0.02	82.84	6.30
RQ091721	2	2	1	200	34.0	32.26	0.02	74.41	5.92
RQ091721	2	3	1	200	34.3	32.26	0.02	76.90	5.81
RQ091721	2	1	2	200	33.9	32.26	3.86	91.61	9.41
RQ091721	2	2	2	200	34.0	32.26	3.86	79.96	8.76
RQ091721	2	3	2	200	34.3	32.26	3.86	84.23	8.94
RQ091721	2	1	3	200	33.9	32.26	36.78	96.11	8.58
RQ091721	2	2	3	200	34.0	32.26	36.78	88.40	8.43
RQ091721	2	3	3	200	34.3	32.26	36.78	96.37	8.49
RQ091722	1	1	1	200	7.4	2.45	0.97	69.79	5.51
RQ091722	1	2	1	200	7.4	2.45	0.97	80.77	5.96
RQ091722	1	3	1	200	6.9	2.45	0.97	78.50	5.82
RQ091722	1	1	2	200	7.4	2.45	4.81	100.53	5.37
RQ091722	1	2	2	200	7.4	2.45	4.81	109.87	5.66
RQ091722	1	3	2	200	6.9	2.45	4.81	95.09	5.22
RQ091722	1	1	3	200	7.4	2.45	34.00	126.92	6.80
RQ091722	1	2	3	200	7.4	2.45	34.00	132.80	6.91
RQ091722	1	3	3	200	6.9	2.45	34.03	123.59	6.59
RQ091722	2	1	1	200	7.3	32.32	0.02	32.37	2.67
RQ091722	2	2	1	200	7.2	32.32	0.02	33.66	2.75
RQ091722	2	3	1	200	8.4	32.32	0.02	34.60	2.83
RQ091722	2	1	2	200	7.3	32.32	3.86	76.50	5.76
RQ091722	2	2	2	200	7.2	32.32	3.86	74.69	5.67
RQ091722	2	3	2	200	8.4	32.32	3.86	78.76	5.95
RQ091722	2	1	3	200	7.3	32.32	36.78	120.93	6.58
RQ091722	2	2	3	200	7.2	32.32	36.90	124.24	6.63
RQ091722	2	3	3	200	8.4	32.32	36.90	123.57	6.86

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091723	1	1	1	200	2.9	2.33	1.05	17.92	1.59
RQ091723	1	2	1	200	2.8	2.33	1.05	20.28	1.70
RQ091723	1	3	1	200	2.8	2.33	1.05	17.56	1.58
RQ091723	1	1	2	200	2.9	2.33	4.96	11.56	1.30
RQ091723	1	2	2	200	2.8	2.33	4.96	12.03	1.33
RQ091723	1	3	2	200	2.8	2.33	4.96	13.23	1.39
RQ091723	1	1	3	200	2.9	2.33	34.03	7.13	1.84
RQ091723	1	2	3	200	2.8	2.33	34.03	7.83	1.90
RQ091723	1	3	3	200	2.8	2.33	34.03	5.88	1.70
RQ091723	2	1	1	200	3.6	32.19	0.18	2.99	0.60
RQ091723	2	2	1	200	3.5	32.19	0.18	3.07	0.59
RQ091723	2	3	1	200	4.0	32.19	0.18	3.41	0.65
RQ091723	2	1	2	200	3.6	32.19	3.74	4.72	1.39
RQ091723	2	2	2	200	3.5	32.19	3.74	5.66	1.54
RQ091723	2	3	2	200	4.0	32.19	3.74	4.36	1.50
RQ091723	2	1	3	200	3.6	32.19	36.91	5.60	1.55
RQ091723	2	2	3	200	3.5	32.19	36.91	5.58	1.68
RQ091723	2	3	3	200	4.0	32.19	36.91	6.80	1.69
RQ091724	1	1	1	200	3.6	2.34	1.05	17.36	1.63
RQ091724	1	2	1	200	3.5	2.34	1.05	16.67	1.57
RQ091724	1	3	1	200	3.4	2.34	1.05	18.03	1.66
RQ091724	1	1	2	200	3.6	2.34	4.96	10.53	1.33
RQ091724	1	2	2	200	3.5	2.34	4.96	9.70	1.23
RQ091724	1	3	2	200	3.4	2.34	4.47	13.33	1.44
RQ091724	1	1	3	200	3.6	2.34	34.03	6.42	1.76
RQ091724	1	2	3	200	3.5	2.34	34.08	7.45	1.98
RQ091724	1	3	3	200	3.4	2.34	34.08	6.03	1.68
RQ091724	2	1	1	200	4.3	32.21	0.18	2.69	0.66
RQ091724	2	2	1	200	4.3	32.21	0.18	3.14	0.60
RQ091724	2	3	1	200	3.7	32.21	0.18	3.35	0.67
RQ091724	2	1	2	200	4.3	32.21	3.74	3.58	1.26
RQ091724	2	2	2	200	4.3	32.21	3.74	4.80	1.52
RQ091724	2	3	2	200	3.7	32.21	3.74	6.18	1.55
RQ091724	2	1	3	200	4.3	32.21	36.91	7.44	1.80
RQ091724	2	2	3	200	4.3	32.21	36.91	8.37	1.84
RQ091724	2	3	3	200	3.7	32.21	36.91	5.94	1.63
RQ091725	1	1	1	200	54.3	2.40	1.05	24.20	3.34
RQ091725	1	2	1	200	52.1	2.40	1.05	24.32	3.35
RQ091725	1	3	1	200	53.4	2.40	1.05	24.83	3.47
RQ091725	1	1	2	200	54.3	2.40	4.47	28.38	3.57
RQ091725	1	2	2	200	52.1	2.40	4.47	27.79	3.53
RQ091725	1	3	2	200	53.4	2.40	4.47	25.98	3.51
RQ091725	1	1	3	200	54.3	2.40	34.08	29.98	4.58
RQ091725	1	2	3	200	52.1	2.40	34.08	30.45	4.58
RQ091725	1	3	3	200	53.4	2.40	34.14	29.15	3.66

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091725	2	1	1	200	50.7	32.26	0.18	8.68	1.63
RQ091725	2	2	1	200	52.6	32.26	0.18	11.08	1.92
RQ091725	2	3	1	200	55.3	32.26	0.18	9.92	1.96
RQ091725	2	1	2	200	50.7	32.26	3.14	16.26	2.18
RQ091725	2	2	2	200	52.6	32.26	3.14	17.10	2.33
RQ091725	2	3	2	200	55.3	32.26	3.74	21.19	3.24
RQ091725	2	1	3	200	50.7	32.26	37.14	26.12	3.60
RQ091725	2	2	3	200	52.6	32.26	37.14	30.59	3.80
RQ091725	2	3	3	200	55.3	32.26	37.14	38.13	4.42
RQ091726	1	1	1	200	48.1	2.40	1.50	23.93	2.10
RQ091726	1	2	1	200	47.4	2.40	1.50	25.21	2.13
RQ091726	1	3	1	200	46.1	2.40	1.50	22.66	2.03
RQ091726	1	1	2	200	48.1	2.40	5.86	27.90	4.16
RQ091726	1	2	2	200	47.4	2.40	5.86	26.81	4.08
RQ091726	1	3	2	200	46.1	2.40	5.86	26.51	4.03
RQ091726	1	1	3	200	48.1	2.40	33.81	34.42	3.72
RQ091726	1	2	3	200	47.4	2.40	33.81	32.82	3.66
RQ091726	1	3	3	200	46.1	2.40	33.81	30.44	3.53
RQ091726	2	1	1	200	49.9	32.26	0.86	9.81	2.80
RQ091726	2	2	1	200	44.6	32.26	0.86	11.70	2.80
RQ091726	2	3	1	200	46.0	32.26	0.86	8.22	2.62
RQ091726	2	1	2	200	49.9	32.26	3.14	16.97	2.17
RQ091726	2	2	2	200	44.6	32.26	3.14	17.17	2.07
RQ091726	2	3	2	200	46.0	32.26	3.14	19.71	2.27
RQ091726	2	1	3	200	49.9	32.26	37.15	26.36	3.41
RQ091726	2	2	3	200	44.6	32.26	37.15	25.23	3.17
RQ091726	2	3	3	200	46.0	32.26	37.72	30.09	4.26
RQ091751	1	1	1	140	71.0	1.40	1.50	91.68	5.69
RQ091751	1	2	1	140	75.1	1.40	1.50	82.73	5.34
RQ091751	1	3	1	140	70.6	1.40	1.50	75.25	4.97
RQ091751	1	1	2	140	71.0	1.40	5.86	55.83	4.35
RQ091751	1	2	2	140	75.1	1.40	5.86	58.24	4.58
RQ091751	1	3	2	140	70.6	1.40	5.90	53.18	4.49
RQ091751	1	1	3	140	71.0	1.40	33.81	47.49	6.53
RQ091751	1	2	3	140	75.1	1.40	33.81	31.70	5.66
RQ091751	1	3	3	140	70.6	1.40	33.81	34.31	5.42
RQ091751	2	1	1	140	69.8	31.26	0.86	20.74	2.99
RQ091751	2	2	1	140	68.9	31.26	0.86	19.14	2.77
RQ091751	2	3	1	140	69.9	31.26	0.86	20.45	2.82
RQ091751	2	1	2	140	69.8	31.26	3.14	28.70	4.06
RQ091751	2	2	2	140	68.9	31.26	3.14	23.40	3.54
RQ091751	2	3	2	140	69.9	31.26	3.14	24.86	3.60
RQ091751	2	1	3	140	69.8	31.26	37.80	46.97	4.24
RQ091751	2	2	3	140	68.9	31.26	37.80	41.04	4.03
RQ091751	2	3	3	140	69.9	31.26	37.86	44.84	4.19

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091992	1	1	1	200	66.1	2.57	0.87	3.34	1.79
RQ091992	1	2	1	200	65.0	2.57	0.93	5.54	1.73
RQ091992	1	3	1	200	66.1	2.57	0.93	4.77	1.63
RQ091992	1	1	2	200	66.1	2.57	4.47	3.57	2.08
RQ091992	1	2	2	200	65.0	2.57	4.47	3.53	1.89
RQ091992	1	3	2	200	66.1	2.57	4.47	3.80	1.98
RQ091992	1	1	3	200	66.1	2.57	32.35	0.63	2.13
RQ091992	1	2	3	200	65.0	2.57	32.35	2.79	1.86
RQ091992	1	3	3	200	66.1	2.57	32.35	2.44	1.99
RQ091992	2	1	1	200	68.0	37.20	0.02	5.60	2.14
RQ091992	2	2	1	200	67.4	37.20	0.02	4.90	2.19
RQ091992	2	3	1	200	65.0	37.20	0.02	5.52	2.29
RQ091992	2	1	2	200	68.0	37.20	9.25	3.65	1.85
RQ091992	2	2	2	200	67.4	37.20	9.25	3.15	1.55
RQ091992	2	3	2	200	65.0	37.20	10.15	4.84	2.47
RQ091992	2	1	3	200	68.0	37.20	43.29	2.19	2.03
RQ091992	2	2	3	200	67.4	37.20	43.29	2.18	2.47
RQ091992	2	3	3	200	65.0	37.20	43.29	2.81	2.00
RQ091993	1	1	1	180	86.4	2.60	0.87	50.49	4.41
RQ091993	1	2	1	180	90.4	2.60	0.87	51.54	4.72
RQ091993	1	3	1	180	90.7	2.60	0.87	48.68	4.48
RQ091993	1	1	2	180	86.4	2.60	4.63	49.79	4.53
RQ091993	1	2	2	180	90.4	2.60	4.63	45.63	4.39
RQ091993	1	3	2	180	90.7	2.60	4.63	44.98	4.57
RQ091993	1	1	3	180	86.4	2.60	32.35	40.22	4.07
RQ091993	1	2	3	180	90.4	2.60	32.35	36.81	3.98
RQ091993	1	3	3	180	90.7	2.60	32.35	35.30	3.59
RQ091993	2	1	1	180	91.1	37.23	0.02	45.91	4.39
RQ091993	2	2	1	180	88.0	37.23	0.05	56.12	4.67
RQ091993	2	3	1	180	90.3	37.23	0.05	37.11	3.96
RQ091993	2	1	2	180	91.1	37.23	9.20	42.32	3.90
RQ091993	2	2	2	180	88.0	37.23	9.20	54.29	4.33
RQ091993	2	3	2	180	90.3	37.23	9.20	35.54	3.63
RQ091993	2	1	3	180	91.1	37.23	43.29	47.05	4.34
RQ091993	2	2	3	180	88.0	37.23	43.29	49.72	4.17
RQ091993	2	3	3	180	90.3	37.23	43.29	32.89	3.59
RQ091994	1	1	1	180	79.2	2.62	0.87	30.91	4.02
RQ091994	1	2	1	180	80.2	2.62	0.87	27.15	3.65
RQ091994	1	3	1	180	81.5	2.62	0.87	21.68	3.37
RQ091994	1	1	2	180	79.2	2.62	4.63	30.61	3.80
RQ091994	1	2	2	180	80.2	2.62	4.68	25.97	3.59
RQ091994	1	3	2	180	81.5	2.62	4.68	20.01	3.08
RQ091994	1	1	3	180	79.2	2.62	32.35	25.42	3.22
RQ091994	1	2	3	180	80.2	2.62	32.35	19.23	3.00
RQ091994	1	3	3	180	81.5	2.62	32.35	19.35	3.13

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091994	2	1	1	180	87.4	36.92	0.37	23.78	3.28
RQ091994	2	2	1	180	84.7	36.92	0.41	29.26	3.77
RQ091994	2	3	1	180	89.8	36.92	1.09	34.71	3.71
RQ091994	2	1	2	180	87.4	36.92	9.54	27.54	3.22
RQ091994	2	2	2	180	84.7	36.92	9.54	34.03	3.45
RQ091994	2	3	2	180	89.8	36.92	9.54	33.13	3.54
RQ091994	2	1	3	180	87.4	36.92	43.61	24.26	3.22
RQ091994	2	2	3	180	84.7	36.92	43.61	25.62	3.22
RQ091994	2	3	3	180	89.8	36.92	43.61	26.50	3.48
RQ091995	1	1	1	200	4.0	2.50	0.44	19.74	2.89
RQ091995	1	2	1	200	3.4	2.50	0.44	24.18	3.21
RQ091995	1	3	1	200	3.4	2.50	0.44	19.68	2.91
RQ091995	1	1	2	200	4.0	2.50	4.38	18.79	2.86
RQ091995	1	2	2	200	3.4	2.50	4.38	14.62	2.53
RQ091995	1	3	2	200	3.4	2.50	4.38	18.18	2.86
RQ091995	1	1	3	200	4.0	2.50	32.35	10.19	2.16
RQ091995	1	2	3	200	3.4	2.50	32.35	8.92	2.04
RQ091995	1	3	3	200	3.4	2.50	32.35	9.94	2.15
RQ091995	2	1	1	200	3.2	36.81	0.25	4.48	1.72
RQ091995	2	2	1	200	3.7	36.81	0.25	4.14	1.52
RQ091995	2	3	1	200	3.6	36.81	0.25	3.81	1.52
RQ091995	2	1	2	200	3.2	36.81	9.47	7.93	1.92
RQ091995	2	2	2	200	3.7	36.81	9.47	7.38	1.88
RQ091995	2	3	2	200	3.6	36.81	9.47	8.30	2.02
RQ091995	2	1	3	200	3.2	36.81	44.13	7.89	1.96
RQ091995	2	2	3	200	3.7	36.81	44.13	8.48	2.12
RQ091995	2	3	3	200	3.6	36.81	44.13	10.51	2.21
RQ091996	1	1	1	200	20.7	2.56	0.44	31.05	4.65
RQ091996	1	2	1	200	20.5	2.56	0.44	27.49	4.36
RQ091996	1	3	1	200	20.7	2.56	0.44	29.69	4.38
RQ091996	1	1	2	200	20.7	2.56	4.39	32.21	4.71
RQ091996	1	2	2	200	20.5	2.56	4.39	33.17	4.60
RQ091996	1	3	2	200	20.7	2.56	4.39	31.86	4.53
RQ091996	1	1	3	200	20.7	2.56	32.73	41.24	5.12
RQ091996	1	2	3	200	20.5	2.56	32.73	31.26	4.55
RQ091996	1	3	3	200	20.7	2.56	32.73	39.49	5.06
RQ091996	2	1	1	200	20.5	36.99	0.13	12.00	2.93
RQ091996	2	2	1	200	21.0	36.99	0.13	13.17	3.14
RQ091996	2	3	1	200	20.9	36.99	0.13	14.05	3.24
RQ091996	2	1	2	200	20.5	36.99	8.09	30.81	4.69
RQ091996	2	2	2	200	21.0	36.99	8.09	34.35	4.91
RQ091996	2	3	2	200	20.9	36.99	8.17	28.35	4.32
RQ091996	2	1	3	200	20.5	36.99	43.41	36.49	5.11
RQ091996	2	2	3	200	21.0	36.99	43.41	41.23	5.33
RQ091996	2	3	3	200	20.9	36.99	43.41	38.82	5.18

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091997	1	1	1	200	20.2	2.55	0.44	19.29	3.54
RQ091997	1	2	1	200	21.1	2.55	0.44	20.59	3.80
RQ091997	1	3	1	200	20.7	2.55	0.44	21.48	3.88
RQ091997	1	1	2	200	20.2	2.55	4.39	25.27	4.11
RQ091997	1	2	2	200	21.1	2.55	4.39	28.42	4.40
RQ091997	1	3	2	200	20.7	2.55	4.46	26.24	4.16
RQ091997	1	1	3	200	20.2	2.55	32.83	38.77	2.99
RQ091997	1	2	3	200	21.1	2.55	32.83	45.60	3.24
RQ091997	1	3	3	200	20.7	2.55	32.83	38.98	3.00
RQ091997	2	1	1	200	22.8	36.98	0.21	13.43	3.45
RQ091997	2	2	1	200	21.9	36.98	0.21	12.34	3.12
RQ091997	2	3	1	200	24.2	36.98	0.21	12.49	3.35
RQ091997	2	1	2	200	22.8	36.98	8.17	32.21	4.79
RQ091997	2	2	2	200	21.9	36.98	8.17	33.80	4.85
RQ091997	2	3	2	200	24.2	36.98	8.17	30.24	4.92
RQ091997	2	1	3	200	22.8	36.98	43.41	31.42	4.67
RQ091997	2	2	3	200	21.9	36.98	43.41	34.63	4.80
RQ091997	2	3	3	200	24.2	36.98	43.41	32.90	4.94
RQ091998	1	1	1	150	69.6	2.61	0.87	27.00	3.59
RQ091998	1	2	1	150	66.3	2.61	0.87	38.67	4.04
RQ091998	1	3	1	150	68.2	2.61	0.87	25.51	3.59
RQ091998	1	1	2	150	69.6	2.61	4.68	28.47	3.35
RQ091998	1	2	2	150	66.3	2.61	4.68	34.86	3.68
RQ091998	1	3	2	150	68.2	2.61	4.68	35.43	3.82
RQ091998	1	1	3	150	69.6	2.61	32.83	31.64	3.47
RQ091998	1	2	3	150	66.3	2.61	32.83	45.22	4.00
RQ091998	1	3	3	150	68.2	2.61	32.83	36.45	3.79
RQ091998	2	1	1	150	88.6	37.05	0.97	14.97	2.39
RQ091998	2	2	1	150	79.9	37.05	0.97	17.91	2.76
RQ091998	2	3	1	150	81.7	37.05	0.97	15.65	3.02
RQ091998	2	1	2	150	88.6	37.05	8.35	29.14	3.24
RQ091998	2	2	2	150	79.9	37.05	8.35	36.99	3.62
RQ091998	2	3	2	150	81.7	37.05	8.35	30.41	3.42
RQ091998	2	1	3	150	88.6	37.05	43.47	23.75	3.19
RQ091998	2	2	3	150	79.9	37.05	43.47	34.08	3.37
RQ091998	2	3	3	150	81.7	37.05	43.47	35.90	3.35
RQ091999	1	1	1	140	57.4	2.58	1.48	55.73	4.95
RQ091999	1	2	1	140	64.0	2.58	1.48	57.62	4.87
RQ091999	1	3	1	140	58.0	2.58	1.48	50.58	4.86
RQ091999	1	1	2	140	57.4	2.58	4.82	54.61	4.70
RQ091999	1	2	2	140	64.0	2.58	4.82	51.67	4.85
RQ091999	1	3	2	140	58.0	2.58	4.89	50.27	4.57
RQ091999	1	1	3	140	57.4	2.58	32.83	50.29	4.16
RQ091999	1	2	3	140	64.0	2.58	33.92	50.94	4.56
RQ091999	1	3	3	140	58.0	2.58	33.92	49.97	4.39

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ091999	2	1	1	140	66.6	37.02	0.96	22.32	2.54
RQ091999	2	2	1	140	78.1	37.02	0.96	27.65	3.10
RQ091999	2	3	1	140	72.0	37.02	0.96	25.05	2.76
RQ091999	2	1	2	140	66.6	37.02	11.14	43.46	3.61
RQ091999	2	2	2	140	78.1	37.02	11.14	49.34	4.19
RQ091999	2	3	2	140	72.0	37.02	11.14	48.36	4.02
RQ091999	2	1	3	140	66.6	37.02	44.11	47.25	4.13
RQ091999	2	2	3	140	78.1	37.02	44.12	50.14	4.15
RQ091999	2	3	3	140	72.0	37.02	44.12	57.10	4.34
RQ092000	1	1	1	200	53.7	2.66	1.48	43.32	5.19
RQ092000	1	2	1	200	63.7	2.66	1.48	48.10	5.04
RQ092000	1	3	1	200	58.6	2.66	1.48	47.20	5.49
RQ092000	1	1	2	200	53.7	2.66	4.47	37.32	4.11
RQ092000	1	2	2	200	63.7	2.66	4.47	40.38	4.62
RQ092000	1	3	2	200	58.6	2.66	4.58	40.31	4.42
RQ092000	1	1	3	200	53.7	2.66	33.92	30.65	3.94
RQ092000	1	2	3	200	63.7	2.66	33.92	29.97	4.13
RQ092000	1	3	3	200	58.6	2.66	33.92	23.86	3.74
RQ092000	2	1	1	200	79.1	37.10	0.96	13.40	1.95
RQ092000	2	2	1	200	71.7	37.10	0.96	13.16	1.61
RQ092000	2	3	1	200	69.5	37.10	0.97	13.27	1.65
RQ092000	2	1	2	200	79.1	37.10	11.14	24.35	3.22
RQ092000	2	2	2	200	71.7	37.10	11.14	29.38	3.48
RQ092000	2	3	2	200	69.5	37.10	11.14	28.99	3.32
RQ092000	2	1	3	200	79.1	37.10	44.12	27.87	3.65
RQ092000	2	2	3	200	71.7	37.10	44.12	30.19	3.80
RQ092000	2	3	3	200	69.5	37.10	44.12	26.07	3.57
RQ092001	1	1	1	200	76.5	2.72	1.48	70.34	5.77
RQ092001	1	2	1	200	73.7	2.72	1.48	84.91	6.56
RQ092001	1	3	1	200	77.4	2.72	1.48	82.09	5.90
RQ092001	1	1	2	200	76.5	2.72	4.58	56.77	5.03
RQ092001	1	2	2	200	73.7	2.72	4.99	83.62	5.50
RQ092001	1	3	2	200	77.4	2.72	5.03	81.74	6.15
RQ092001	1	1	3	200	76.5	2.72	33.92	57.19	4.93
RQ092001	1	2	3	200	73.7	2.72	33.92	59.55	4.98
RQ092001	1	3	3	200	77.4	2.72	33.92	60.84	5.24
RQ092001	2	1	1	200	77.1	37.35	0.76	26.63	2.31
RQ092001	2	2	1	200	81.5	37.35	0.76	27.92	2.48
RQ092001	2	3	1	200	71.4	37.35	1.75	30.06	3.69
RQ092001	2	1	2	200	77.1	37.35	10.94	56.53	4.42
RQ092001	2	2	2	200	81.5	37.35	10.94	55.07	4.50
RQ092001	2	3	2	200	71.4	37.35	10.94	60.53	4.50
RQ092001	2	1	3	200	77.1	37.35	43.80	50.38	4.82
RQ092001	2	2	3	200	81.5	37.35	43.92	53.85	4.48
RQ092001	2	3	3	200	71.4	37.35	43.92	59.95	4.91

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092029	1	1	1	200	58.2	1.66	1.48	9.30	2.53
RQ092029	1	2	1	200	58.7	1.66	1.48	6.15	2.39
RQ092029	1	3	1	200	58.7	1.66	1.49	5.23	2.48
RQ092029	1	1	2	200	58.2	1.66	4.47	5.39	2.77
RQ092029	1	2	2	200	58.7	1.66	4.47	6.50	2.61
RQ092029	1	3	2	200	58.7	1.66	4.47	6.80	2.89
RQ092029	1	1	3	200	58.2	1.66	33.92	4.07	2.10
RQ092029	1	2	3	200	58.7	1.66	34.49	6.27	2.43
RQ092029	1	3	3	200	58.7	1.66	34.49	4.76	2.16
RQ092029	2	1	1	200	79.8	35.97	0.40	4.89	1.83
RQ092029	2	2	1	200	90.8	35.97	0.40	5.93	2.20
RQ092029	2	3	1	200	94.7	35.97	0.40	7.56	2.15
RQ092029	2	1	2	200	79.8	35.97	10.47	5.77	2.02
RQ092029	2	2	2	200	90.8	35.97	10.47	3.48	1.79
RQ092029	2	3	2	200	94.7	35.97	10.47	5.30	2.25
RQ092029	2	1	3	200	79.8	35.97	44.35	3.45	1.84
RQ092029	2	2	3	200	90.8	35.97	44.35	4.25	1.76
RQ092029	2	3	3	200	94.7	35.97	44.35	3.98	2.23
RQ092250	1	1	1	100	97.8	4.59	0.96	33.78	3.13
RQ092250	1	2	1	100	99.6	4.59	0.96	35.60	3.31
RQ092250	1	3	1	100	85.6	4.59	0.96	33.05	3.05
RQ092250	1	1	2	100	97.8	4.59	5.87	32.10	3.55
RQ092250	1	2	2	100	99.6	4.59	5.87	31.70	3.38
RQ092250	1	3	2	100	85.6	4.59	5.87	31.86	2.93
RQ092250	1	1	3	100	97.8	4.59	43.03	27.94	3.05
RQ092250	1	2	3	100	99.6	4.59	43.03	29.22	3.46
RQ092250	1	3	3	100	85.6	4.59	43.03	27.77	2.78
RQ092250	2	1	1	100	71.5	50.16	0.02	20.32	2.96
RQ092250	2	2	1	100	67.6	50.04	0.14	22.47	2.80
RQ092250	2	3	1	100	68.7	50.04	0.14	23.80	3.01
RQ092250	2	1	2	100	71.5	50.16	3.32	20.22	2.83
RQ092250	2	2	2	100	67.6	50.04	3.45	19.47	2.56
RQ092250	2	3	2	100	68.7	50.04	3.45	22.24	2.84
RQ092250	2	1	3	100	71.5	50.16	32.99	20.77	2.94
RQ092250	2	2	3	100	67.6	50.04	33.12	24.10	2.91
RQ092250	2	3	3	100	68.7	50.04	33.12	25.16	3.10
RQ092251	1	1	1	200	56.4	4.57	2.00	14.82	2.19
RQ092251	1	2	1	200	55.1	4.57	2.00	14.99	2.20
RQ092251	1	3	1	200	60.4	4.57	2.00	15.29	2.37
RQ092251	1	1	2	200	56.4	4.57	5.68	19.26	3.58
RQ092251	1	2	2	200	55.1	4.57	6.62	20.98	3.35
RQ092251	1	3	2	200	60.4	4.57	6.62	19.76	3.46
RQ092251	1	1	3	200	56.4	4.57	43.64	25.34	2.53
RQ092251	1	2	3	200	55.1	4.57	43.64	25.24	2.46
RQ092251	1	3	3	200	60.4	4.57	43.64	23.64	2.55

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092251	2	1	1	200	53.4	50.02	0.14	7.34	2.70
RQ092251	2	2	1	200	58.6	50.02	0.24	9.80	2.82
RQ092251	2	3	1	200	59.6	50.02	0.14	8.92	3.02
RQ092251	2	1	2	200	53.4	50.02	3.45	15.15	3.04
RQ092251	2	2	2	200	58.6	50.02	3.45	12.87	2.85
RQ092251	2	3	2	200	59.6	50.02	3.45	13.95	3.17
RQ092251	2	1	3	200	53.4	50.02	32.45	20.62	3.25
RQ092251	2	2	3	200	58.6	50.02	32.45	20.99	3.59
RQ092251	2	3	3	200	59.6	50.02	32.45	17.75	3.09
RQ092252	1	1	1	100	74.0	4.54	0.96	30.52	3.21
RQ092252	1	2	1	100	85.1	4.54	2.00	33.36	3.49
RQ092252	1	3	1	100	72.4	4.54	2.00	34.00	3.54
RQ092252	1	1	2	100	74.0	4.54	5.87	50.10	3.83
RQ092252	1	2	2	100	85.1	4.54	5.87	44.45	3.16
RQ092252	1	3	2	100	72.4	4.54	5.87	48.52	3.46
RQ092252	1	1	3	100	74.0	4.54	43.03	53.59	3.45
RQ092252	1	2	3	100	85.1	4.54	43.03	48.77	3.37
RQ092252	1	3	3	100	72.4	4.54	43.03	59.82	3.32
RQ092252	2	1	1	100	79.4	49.99	0.14	18.97	2.95
RQ092252	2	2	1	100	79.1	49.99	0.14	15.85	3.00
RQ092252	2	3	1	100	76.4	49.99	0.14	15.07	2.65
RQ092252	2	1	2	100	79.4	49.99	3.45	37.91	3.63
RQ092252	2	2	2	100	79.1	49.99	3.45	33.91	3.68
RQ092252	2	3	2	100	76.4	49.99	3.45	29.88	3.16
RQ092252	2	1	3	100	79.4	49.99	33.12	58.20	4.87
RQ092252	2	2	3	100	79.1	49.99	33.12	65.37	4.77
RQ092252	2	3	3	100	76.4	49.99	33.12	59.52	4.70
RQ092253	1	1	1	125	82.5	4.59	2.00	25.76	3.19
RQ092253	1	2	1	125	82.1	4.59	2.00	23.98	3.16
RQ092253	1	3	1	125	84.1	4.59	2.00	26.79	3.25
RQ092253	1	1	2	125	82.5	4.59	5.95	26.13	2.92
RQ092253	1	2	2	125	82.1	4.59	5.95	24.08	2.85
RQ092253	1	3	2	125	84.1	4.59	5.95	25.94	3.11
RQ092253	1	1	3	125	82.5	4.59	43.03	22.22	2.80
RQ092253	1	2	3	125	82.1	4.59	43.03	24.49	3.02
RQ092253	1	3	3	125	84.1	4.59	43.65	29.44	3.52
RQ092253	2	1	1	125	89.5	50.04	0.14	22.67	2.80
RQ092253	2	2	1	125	79.3	50.04	0.15	23.23	2.77
RQ092253	2	3	1	125	87.3	50.04	0.15	23.41	3.07
RQ092253	2	1	2	125	89.5	50.04	3.45	20.41	2.63
RQ092253	2	2	2	125	79.3	50.04	3.45	22.49	2.62
RQ092253	2	3	2	125	87.3	50.04	3.45	22.38	2.94
RQ092253	2	1	3	125	89.5	50.04	33.12	24.44	3.04
RQ092253	2	2	3	125	79.3	50.04	33.12	20.89	2.94
RQ092253	2	3	3	125	87.3	50.04	33.12	21.97	2.72

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092254	1	1	1	200	97.3	4.53	0.03	26.63	3.47
RQ092254	1	2	1	200	94.3	4.53	0.60	20.05	3.03
RQ092254	1	3	1	200	97.4	4.53	0.60	26.06	3.32
RQ092254	1	1	2	200	97.3	4.53	5.49	22.71	3.20
RQ092254	1	2	2	200	94.3	4.53	5.50	18.18	3.05
RQ092254	1	3	2	200	97.4	4.53	5.50	22.14	3.16
RQ092254	1	1	3	200	97.3	4.53	41.95	24.17	3.55
RQ092254	1	2	3	200	94.3	4.53	41.95	15.56	2.68
RQ092254	1	3	3	200	97.4	4.53	42.64	20.49	3.22
RQ092254	2	1	1	200	93.0	50.03	0.47	22.23	3.48
RQ092254	2	2	1	200	90.0	50.03	0.47	18.32	2.99
RQ092254	2	3	1	200	94.3	50.03	0.47	18.51	3.32
RQ092254	2	1	2	200	93.0	50.03	4.15	21.58	3.34
RQ092254	2	2	2	200	90.0	50.03	4.15	18.52	2.87
RQ092254	2	3	2	200	94.3	50.03	4.15	21.48	3.36
RQ092254	2	1	3	200	93.0	50.03	33.03	21.61	3.03
RQ092254	2	2	3	200	90.0	50.03	33.03	18.22	2.74
RQ092254	2	3	3	200	94.3	50.03	33.03	16.33	3.03
RQ092255	1	1	1	200	27.7	4.59	0.60	15.18	2.62
RQ092255	1	2	1	200	26.8	4.59	0.60	15.83	2.77
RQ092255	1	3	1	200	26.2	4.59	0.61	11.99	2.33
RQ092255	1	1	2	200	27.7	4.59	5.41	19.14	4.04
RQ092255	1	2	2	200	26.8	4.59	5.41	20.92	4.21
RQ092255	1	3	2	200	26.2	4.59	5.41	17.78	4.04
RQ092255	1	1	3	200	27.7	4.59	42.64	22.14	3.08
RQ092255	1	2	3	200	26.8	4.59	42.64	17.62	2.86
RQ092255	1	3	3	200	26.2	4.59	42.64	19.80	2.88
RQ092255	2	1	1	200	26.2	50.09	1.45	9.66	1.74
RQ092255	2	2	1	200	25.4	50.09	1.45	9.52	1.65
RQ092255	2	3	1	200	26.2	50.09	1.45	9.57	1.74
RQ092255	2	1	2	200	26.2	50.09	5.15	16.14	2.56
RQ092255	2	2	2	200	25.4	50.09	5.15	12.51	2.33
RQ092255	2	3	2	200	26.2	50.09	5.15	14.47	2.56
RQ092255	2	1	3	200	26.2	50.09	32.37	19.03	2.88
RQ092255	2	2	3	200	25.4	50.09	34.95	16.45	3.65
RQ092255	2	3	3	200	26.2	50.09	34.95	21.49	4.17
RQ092256	1	1	1	200	33.2	4.62	0.61	118.62	7.44
RQ092256	1	2	1	200	32.3	4.62	0.61	108.84	7.06
RQ092256	1	3	1	200	31.9	4.62	0.61	105.82	6.91
RQ092256	1	1	2	200	33.2	4.62	5.41	107.42	8.96
RQ092256	1	2	2	200	32.3	4.62	5.41	115.98	9.42
RQ092256	1	3	2	200	31.9	4.62	5.41	104.58	8.90
RQ092256	1	1	3	200	33.2	4.62	42.64	99.52	6.87
RQ092256	1	2	3	200	32.3	4.62	42.64	116.92	7.30
RQ092256	1	3	3	200	31.9	4.62	42.64	97.58	6.63

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092256	2	1	1	200	32.7	50.13	1.45	119.07	5.84
RQ092256	2	2	1	200	36.2	50.13	1.45	97.75	5.60
RQ092256	2	3	1	200	35.8	50.13	1.45	110.17	6.06
RQ092256	2	1	2	200	32.7	50.13	5.41	112.35	6.99
RQ092256	2	2	2	200	36.2	50.13	5.41	101.50	6.88
RQ092256	2	3	2	200	35.8	50.13	5.42	106.63	7.13
RQ092256	2	1	3	200	32.7	50.13	34.95	110.38	9.74
RQ092256	2	2	3	200	36.2	50.13	34.95	103.69	9.90
RQ092256	2	3	3	200	35.8	50.13	34.95	110.56	10.26
RQ092257	1	1	1	200	70.5	5.18	0.07	304.92	11.42
RQ092257	1	2	1	200	68.3	5.18	0.07	295.05	11.05
RQ092257	1	3	1	200	72.4	5.18	0.07	303.74	11.65
RQ092257	1	1	2	200	70.5	5.18	4.96	304.23	10.80
RQ092257	1	2	2	200	68.3	5.18	4.96	273.85	10.48
RQ092257	1	3	2	200	72.4	5.18	4.96	287.44	10.51
RQ092257	1	1	3	200	70.5	5.18	41.44	292.52	8.93
RQ092257	1	2	3	200	68.3	5.18	41.44	290.28	8.36
RQ092257	1	3	3	200	72.4	5.18	41.44	301.70	8.88
RQ092257	2	1	1	200	60.6	50.15	1.45	283.61	9.62
RQ092257	2	2	1	200	62.4	50.15	1.45	285.47	9.93
RQ092257	2	3	1	200	62.2	50.15	1.45	288.89	9.85
RQ092257	2	1	2	200	60.6	50.15	5.42	273.53	11.63
RQ092257	2	2	2	200	62.4	50.15	5.42	303.63	12.40
RQ092257	2	3	2	200	62.2	50.15	5.42	278.41	11.74
RQ092257	2	1	3	200	60.6	50.15	32.20	297.10	12.13
RQ092257	2	2	3	200	62.4	50.15	32.20	327.44	12.74
RQ092257	2	3	3	200	62.2	50.15	32.20	325.45	12.09
RQ092258	1	1	1	200	25.2	5.07	0.39	8.40	1.38
RQ092258	1	2	1	200	25.1	5.07	0.39	7.90	1.22
RQ092258	1	3	1	200	25.0	5.07	0.39	9.71	1.36
RQ092258	1	1	2	200	25.2	5.07	4.88	15.80	3.62
RQ092258	1	2	2	200	25.1	5.07	4.88	13.75	3.47
RQ092258	1	3	2	200	25.0	5.07	4.87	20.43	3.96
RQ092258	1	1	3	200	25.2	5.07	42.11	23.81	3.01
RQ092258	1	2	3	200	25.1	5.07	42.11	19.07	2.69
RQ092258	1	3	3	200	25.0	5.07	42.11	25.25	3.14
RQ092258	2	1	1	200	25.0	50.04	1.92	10.42	3.04
RQ092258	2	2	1	200	25.0	50.04	1.92	12.32	3.18
RQ092258	2	3	1	200	25.5	50.04	1.92	10.54	3.11
RQ092258	2	1	2	200	25.0	50.04	5.42	14.49	1.96
RQ092258	2	2	2	200	25.0	50.04	5.42	15.73	2.08
RQ092258	2	3	2	200	25.5	50.04	5.42	13.85	2.03
RQ092258	2	1	3	200	25.0	50.04	32.20	19.34	3.87
RQ092258	2	2	3	200	25.0	50.04	32.20	20.56	4.12
RQ092258	2	3	3	200	25.5	50.04	32.36	19.18	2.75

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092847	1	1	1	200	14.1	3.51	0.57	35.23	4.33
RQ092847	1	2	1	200	15.6	3.51	0.57	36.66	4.49
RQ092847	1	3	1	200	15.6	3.51	0.57	35.57	4.50
RQ092847	1	1	2	200	14.1	3.51	4.90	32.78	2.42
RQ092847	1	2	2	200	15.6	3.51	4.90	35.07	2.58
RQ092847	1	3	2	200	15.6	3.51	4.90	35.51	2.59
RQ092847	1	1	3	200	14.1	3.51	42.86	30.82	4.05
RQ092847	1	2	3	200	15.6	3.51	42.86	33.36	4.38
RQ092847	1	3	3	200	15.6	3.51	42.86	35.71	4.50
RQ092847	2	1	1	200	18.0	34.17	0.86	33.80	4.49
RQ092847	2	2	1	200	12.7	34.17	0.86	25.94	3.71
RQ092847	2	3	1	200	19.8	34.17	0.86	41.41	5.15
RQ092847	2	1	2	200	18.0	34.17	3.77	37.12	4.69
RQ092847	2	2	2	200	12.7	34.17	3.77	27.73	3.84
RQ092847	2	3	2	200	19.8	34.17	3.77	40.84	5.11
RQ092847	2	1	3	200	18.0	34.17	39.20	37.09	4.73
RQ092847	2	2	3	200	12.7	34.17	39.20	31.80	4.17
RQ092847	2	3	3	200	19.8	34.17	39.20	42.56	5.25
RQ092848	1	1	1	200	15.5	3.45	0.64	88.95	6.88
RQ092848	1	2	1	200	15.4	3.45	0.64	85.32	6.73
RQ092848	1	3	1	200	17.3	3.45	0.64	94.57	7.37
RQ092848	1	1	2	200	15.5	3.45	4.90	67.95	11.28
RQ092848	1	2	2	200	15.4	3.45	4.90	77.42	3.88
RQ092848	1	3	2	200	17.3	3.45	5.36	85.06	6.91
RQ092848	1	1	3	200	15.5	3.45	42.86	77.42	6.60
RQ092848	1	2	3	200	15.4	3.45	42.86	70.19	6.40
RQ092848	1	3	3	200	17.3	3.45	42.86	90.54	7.41
RQ092848	2	1	1	200	19.9	34.10	0.86	79.74	7.07
RQ092848	2	2	1	200	21.4	34.10	0.86	82.31	7.43
RQ092848	2	3	1	200	17.5	34.10	0.86	77.08	6.93
RQ092848	2	1	2	200	19.9	34.10	3.77	72.23	6.76
RQ092848	2	2	2	200	21.4	34.10	3.77	78.65	7.26
RQ092848	2	3	2	200	17.5	34.10	3.77	69.51	6.59
RQ092848	2	1	3	200	19.9	34.10	39.20	71.83	6.82
RQ092848	2	2	3	200	21.4	34.10	39.20	82.12	7.56
RQ092848	2	3	3	200	17.5	34.10	39.20	77.58	6.90
RQ092849	1	1	1	200	21.6	3.62	0.78	55.53	5.98
RQ092849	1	2	1	200	22.2	3.62	0.78	49.06	5.78
RQ092849	1	3	1	200	22.9	3.62	0.78	50.27	5.88
RQ092849	1	1	2	200	21.6	3.62	5.36	52.56	5.94
RQ092849	1	2	2	200	22.2	3.62	5.36	54.27	6.05
RQ092849	1	3	2	200	22.9	3.62	5.36	55.43	6.24
RQ092849	1	1	3	200	21.6	3.62	42.86	50.33	5.73
RQ092849	1	2	3	200	22.2	3.62	42.86	47.52	5.62
RQ092849	1	3	3	200	22.9	3.62	42.86	43.81	5.50

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092849	2	1	1	200	24.1	34.27	0.86	46.64	5.95
RQ092849	2	2	1	200	24.8	34.27	0.86	51.01	6.29
RQ092849	2	3	1	200	24.7	34.27	0.86	45.06	5.68
RQ092849	2	1	2	200	24.1	34.27	3.77	49.56	6.14
RQ092849	2	2	2	200	24.8	34.27	3.77	52.88	6.40
RQ092849	2	3	2	200	24.7	34.27	3.77	47.04	5.79
RQ092849	2	1	3	200	24.1	34.27	39.20	50.95	6.21
RQ092849	2	2	3	200	24.8	34.27	39.20	52.02	6.12
RQ092849	2	3	3	200	24.7	34.27	39.20	52.59	6.11
RQ092850	1	1	1	200	16.7	3.67	0.79	14.66	3.05
RQ092850	1	2	1	200	16.2	3.67	0.85	15.00	3.00
RQ092850	1	3	1	200	16.0	3.67	0.85	19.11	3.40
RQ092850	1	1	2	200	16.7	3.67	5.84	12.65	1.66
RQ092850	1	2	2	200	16.2	3.67	5.84	13.39	1.67
RQ092850	1	3	2	200	16.0	3.67	5.84	15.81	1.81
RQ092850	1	1	3	200	16.7	3.67	43.54	14.50	3.01
RQ092850	1	2	3	200	16.2	3.67	43.54	12.53	2.82
RQ092850	1	3	3	200	16.0	3.67	43.54	15.18	3.09
RQ092850	2	1	1	200	20.4	34.34	1.01	19.33	3.63
RQ092850	2	2	1	200	19.1	34.34	1.01	15.04	3.17
RQ092850	2	3	1	200	21.5	34.34	1.01	16.63	3.52
RQ092850	2	1	2	200	20.4	34.34	3.85	19.65	3.65
RQ092850	2	2	2	200	19.1	34.34	3.85	17.67	3.42
RQ092850	2	3	2	200	21.5	34.34	3.85	17.50	3.59
RQ092850	2	1	3	200	20.4	34.34	39.77	15.76	3.38
RQ092850	2	2	3	200	19.1	34.34	39.77	14.25	3.28
RQ092850	2	3	3	200	21.5	34.34	39.77	17.48	3.64
RQ092851	1	1	1	200	22.4	3.69	0.85	13.28	3.29
RQ092851	1	2	1	200	21.5	3.69	0.87	13.60	3.20
RQ092851	1	3	1	200	25.9	3.69	1.88	12.05	1.98
RQ092851	1	1	2	200	22.4	3.69	5.84	10.84	1.82
RQ092851	1	2	2	200	21.5	3.69	5.84	14.61	1.91
RQ092851	1	3	2	200	25.9	3.69	5.84	10.91	1.93
RQ092851	1	1	3	200	22.4	3.69	43.54	11.69	3.31
RQ092851	1	2	3	200	21.5	3.69	43.54	13.16	3.20
RQ092851	1	3	3	200	25.9	3.69	43.54	9.51	3.15
RQ092851	2	1	1	200	28.5	34.36	1.01	14.61	3.88
RQ092851	2	2	1	200	33.2	34.36	1.01	12.58	3.75
RQ092851	2	3	1	200	27.8	34.36	1.01	12.91	3.68
RQ092851	2	1	2	200	28.5	34.36	3.85	13.92	3.83
RQ092851	2	2	2	200	33.2	34.36	3.85	16.09	4.12
RQ092851	2	3	2	200	27.8	34.36	3.85	18.17	4.20
RQ092851	2	1	3	200	28.5	34.36	39.77	15.66	3.90
RQ092851	2	2	3	200	33.2	34.36	39.77	17.37	4.40
RQ092851	2	3	3	200	27.8	34.36	39.85	12.35	3.45

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092852	1	1	1	200	23.0	3.41	1.88	209.05	6.76
RQ092852	1	2	1	200	22.8	3.41	1.88	222.93	6.93
RQ092852	1	3	1	200	23.2	3.41	1.88	194.77	6.61
RQ092852	1	1	2	200	23.0	3.41	5.84	207.17	7.01
RQ092852	1	2	2	200	22.8	3.41	5.84	221.83	7.17
RQ092852	1	3	2	200	23.2	3.41	5.84	185.93	6.40
RQ092852	1	1	3	200	23.0	3.41	43.64	188.55	11.05
RQ092852	1	2	3	200	22.8	3.41	43.64	223.52	12.29
RQ092852	1	3	3	200	23.2	3.41	43.64	181.34	11.02
RQ092852	2	1	1	200	31.3	34.07	1.01	262.42	15.22
RQ092852	2	2	1	200	26.9	34.07	1.01	236.31	13.57
RQ092852	2	3	1	200	30.6	34.07	1.01	231.38	13.53
RQ092852	2	1	2	200	31.3	34.07	3.85	265.01	15.30
RQ092852	2	2	2	200	26.9	34.07	3.85	222.11	13.16
RQ092852	2	3	2	200	30.6	34.07	3.85	217.99	13.14
RQ092852	2	1	3	200	31.3	34.07	39.77	263.30	15.11
RQ092852	2	2	3	200	26.9	34.07	39.77	206.41	12.25
RQ092852	2	3	3	200	30.6	34.07	39.77	212.00	12.92
RQ092853	1	1	1	200	26.6	3.43	1.89	260.56	7.85
RQ092853	1	2	1	200	22.2	3.43	2.59	265.66	7.47
RQ092853	1	3	1	200	22.7	3.43	2.59	309.63	8.33
RQ092853	1	1	2	200	26.6	3.43	4.50	267.79	7.95
RQ092853	1	2	2	200	22.2	3.43	4.50	263.46	7.63
RQ092853	1	3	2	200	22.7	3.43	4.50	314.37	8.29
RQ092853	1	1	3	200	26.6	3.43	42.94	233.97	9.11
RQ092853	1	2	3	200	22.2	3.43	42.94	261.15	9.31
RQ092853	1	3	3	200	22.7	3.43	42.94	297.30	9.87
RQ092853	2	1	1	200	23.8	34.11	0.04	285.86	9.70
RQ092853	2	2	1	200	28.2	34.11	0.04	286.66	10.53
RQ092853	2	3	1	200	23.4	34.11	0.04	295.87	9.95
RQ092853	2	1	2	200	23.8	34.11	3.91	291.79	13.86
RQ092853	2	2	2	200	28.2	34.11	3.91	293.29	15.07
RQ092853	2	3	2	200	23.4	34.11	3.91	312.91	14.45
RQ092853	2	1	3	200	23.8	34.11	39.84	329.47	15.20
RQ092853	2	2	3	200	28.2	34.11	39.84	304.76	15.76
RQ092853	2	3	3	200	23.4	34.11	39.84	341.08	15.65
RQ092854	1	1	1	200	33.5	3.77	2.59	12.08	2.11
RQ092854	1	2	1	200	33.0	3.77	2.59	13.61	2.34
RQ092854	1	3	1	200	33.2	3.77	2.59	12.09	2.08
RQ092854	1	1	2	200	33.5	3.77	4.50	6.47	1.89
RQ092854	1	2	2	200	33.0	3.77	4.50	9.28	1.88
RQ092854	1	3	2	200	33.2	3.77	4.50	9.07	2.02
RQ092854	1	1	3	200	33.5	3.77	42.94	3.32	2.09
RQ092854	1	2	3	200	33.0	3.77	42.94	3.72	1.76
RQ092854	1	3	3	200	33.2	3.77	42.94	2.34	1.73

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RQ092854	2	1	1	200	41.6	34.46	0.04	4.62	2.39
RQ092854	2	2	1	200	30.1	34.46	0.04	2.85	1.54
RQ092854	2	3	1	200	34.9	34.46	0.04	3.13	1.96
RQ092854	2	1	2	200	41.6	34.46	3.91	7.03	3.77
RQ092854	2	2	2	200	30.1	34.46	3.91	2.06	2.05
RQ092854	2	3	2	200	34.9	34.46	3.91	2.57	2.61
RQ092854	2	1	3	200	41.6	34.46	39.84	5.02	3.21
RQ092854	2	2	3	200	30.1	34.46	39.84	4.80	2.50
RQ092854	2	3	3	200	34.9	34.46	39.84	4.74	2.69
RQ092855	1	1	1	150	98.2	3.67	0.91	89.15	5.34
RQ092855	1	2	1	150	81.7	3.67	0.93	75.09	4.52
RQ092855	1	3	1	150	90.6	3.67	0.93	76.29	4.89
RQ092855	1	1	2	150	98.2	3.67	4.50	85.23	5.46
RQ092855	1	2	2	150	81.7	3.67	4.50	70.38	4.62
RQ092855	1	3	2	150	90.6	3.67	4.50	67.95	4.57
RQ092855	1	1	3	150	98.2	3.67	42.94	70.32	5.05
RQ092855	1	2	3	150	81.7	3.67	42.94	57.30	4.34
RQ092855	1	3	3	150	90.6	3.67	42.94	54.72	4.14
RQ092855	2	1	1	150	110.0	34.35	0.04	102.90	6.36
RQ092855	2	2	1	150	118.9	34.35	0.04	120.06	7.41
RQ092855	2	3	1	150	119.6	34.35	0.04	97.57	6.08
RQ092855	2	1	2	150	110.0	34.35	3.98	103.13	6.39
RQ092855	2	2	2	150	118.9	34.35	3.98	117.02	7.33
RQ092855	2	3	2	150	119.6	34.35	3.98	102.43	6.20
RQ092855	2	1	3	150	110.0	34.35	39.96	95.80	7.19
RQ092855	2	2	3	150	118.9	34.35	39.96	99.00	7.53
RQ092855	2	3	3	150	119.6	34.35	39.96	98.48	7.83
RQ092856	1	1	1	150	76.7	3.65	0.93	51.27	3.87
RQ092856	1	2	1	150	90.0	3.65	0.94	68.58	4.72
RQ092856	1	3	1	150	82.6	3.65	1.89	54.66	4.10
RQ092856	1	1	2	150	76.7	3.65	4.50	45.98	3.53
RQ092856	1	2	2	150	90.0	3.65	4.50	64.68	4.54
RQ092856	1	3	2	150	82.6	3.65	4.50	50.00	3.98
RQ092856	1	1	3	150	76.7	3.65	42.94	40.72	3.40
RQ092856	1	2	3	150	90.0	3.65	42.94	57.30	4.22
RQ092856	1	3	3	150	82.6	3.65	42.94	45.26	3.91
RQ092856	2	1	1	150	96.9	34.33	0.04	90.06	5.36
RQ092856	2	2	1	150	117.5	34.33	0.04	97.06	6.23
RQ092856	2	3	1	150	110.7	34.33	0.04	98.14	6.10
RQ092856	2	1	2	150	96.9	34.33	3.98	84.14	5.21
RQ092856	2	2	2	150	117.5	34.33	3.98	87.71	5.95
RQ092856	2	3	2	150	110.7	34.33	3.98	87.71	5.86
RQ092856	2	1	3	150	96.9	34.33	39.96	78.63	6.38
RQ092856	2	2	3	150	117.5	34.33	40.16	85.58	7.45
RQ092856	2	3	3	150	110.7	34.33	40.16	91.18	7.59

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093078	1	1	1	200	47.0	3.07	0.36	36.74	5.29
RR093078	1	2	1	200	47.5	3.07	0.36	42.57	5.58
RR093078	1	3	1	200	47.4	3.07	0.36	40.69	5.68
RR093078	1	1	2	200	47.0	3.07	5.48	33.74	3.89
RR093078	1	2	2	200	47.5	3.07	5.48	34.91	3.97
RR093078	1	3	2	200	47.4	3.07	5.48	38.76	4.10
RR093078	1	1	3	200	47.0	3.07	170.10	37.63	4.14
RR093078	1	2	3	200	47.5	3.07	170.13	39.97	4.28
RR093078	1	3	3	200	47.4	3.07	170.13	36.75	4.16
RR093078	2	1	1	200	46.5	46.12	4.12	39.27	5.02
RR093078	2	2	1	200	45.2	46.12	4.12	33.08	4.34
RR093078	2	3	1	200	47.8	46.12	4.12	36.71	4.66
RR093078	2	1	2	200	46.5	46.12	5.96	34.25	4.57
RR093078	2	2	2	200	45.2	46.12	6.01	38.46	5.03
RR093078	2	3	2	200	47.8	46.12	6.05	37.10	4.84
RR093078	2	1	3	200	46.5	46.12	41.20	33.80	3.77
RR093078	2	2	3	200	45.2	46.12	41.20	28.57	3.54
RR093078	2	3	3	200	47.8	46.12	41.20	37.88	4.14
RR093079	1	1	1	200	45.2	3.10	0.48	18.61	3.69
RR093079	1	2	1	200	45.5	3.10	0.48	20.54	3.67
RR093079	1	3	1	200	45.3	3.10	0.48	20.36	3.84
RR093079	1	1	2	200	45.2	3.10	5.48	28.70	3.59
RR093079	1	2	2	200	45.5	3.10	5.48	34.30	3.63
RR093079	1	3	2	200	45.3	3.10	5.48	35.44	3.68
RR093079	1	1	3	200	45.2	3.10	170.13	44.10	4.29
RR093079	1	2	3	200	45.5	3.10	170.13	48.44	4.31
RR093079	1	3	3	200	45.3	3.10	170.13	50.36	4.36
RR093079	2	1	1	200	46.0	46.15	4.12	30.51	4.24
RR093079	2	2	1	200	45.7	46.15	4.12	28.70	4.23
RR093079	2	3	1	200	45.9	46.15	4.15	30.77	4.38
RR093079	2	1	2	200	46.0	46.15	6.05	33.89	4.66
RR093079	2	2	2	200	45.7	46.15	6.05	33.47	4.64
RR093079	2	3	2	200	45.9	46.15	6.05	31.62	4.30
RR093079	2	1	3	200	46.0	46.15	41.21	44.92	4.34
RR093079	2	2	3	200	45.7	46.15	41.21	49.58	4.58
RR093079	2	3	3	200	45.9	46.15	41.21	40.65	3.93
RR093080	1	1	1	200	32.4	3.19	0.12	15.06	3.86
RR093080	1	2	1	200	32.1	3.19	0.12	16.50	4.01
RR093080	1	3	1	200	30.6	3.19	0.12	9.27	3.40
RR093080	1	1	2	200	32.4	3.19	5.95	11.12	3.44
RR093080	1	2	2	200	32.1	3.19	5.95	8.49	3.08
RR093080	1	3	2	200	30.6	3.19	5.95	8.78	3.16
RR093080	1	1	3	200	32.4	3.19	170.01	10.95	3.08
RR093080	1	2	3	200	32.1	3.19	170.01	11.79	3.18
RR093080	1	3	3	200	30.6	3.19	170.01	11.23	2.93

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093080	2	1	1	200	34.4	46.24	4.15	7.90	2.37
RR093080	2	2	1	200	39.4	46.24	4.15	7.89	2.51
RR093080	2	3	1	200	34.4	46.24	4.84	7.32	2.32
RR093080	2	1	2	200	34.4	46.24	5.86	6.31	2.54
RR093080	2	2	2	200	39.4	46.24	5.95	7.75	2.53
RR093080	2	3	2	200	34.4	46.24	5.95	6.42	2.34
RR093080	2	1	3	200	34.4	46.24	41.22	8.41	1.85
RR093080	2	2	3	200	39.4	46.24	41.22	9.76	2.03
RR093080	2	3	3	200	34.4	46.24	41.22	8.84	2.02
RR093081	1	1	1	200	34.0	3.22	0.18	159.01	10.77
RR093081	1	2	1	200	35.1	3.22	0.18	164.95	11.30
RR093081	1	3	1	200	34.2	3.22	0.18	160.92	11.32
RR093081	1	1	2	200	34.0	3.22	5.94	87.02	8.19
RR093081	1	2	2	200	35.1	3.22	5.94	93.12	8.75
RR093081	1	3	2	200	34.2	3.22	5.94	91.57	8.57
RR093081	1	1	3	200	34.0	3.22	170.00	90.28	7.26
RR093081	1	2	3	200	35.1	3.22	170.00	88.99	7.36
RR093081	1	3	3	200	34.2	3.22	170.09	132.10	8.78
RR093081	2	1	1	200	35.7	46.27	4.83	52.71	5.84
RR093081	2	2	1	200	37.0	46.27	4.83	42.85	5.57
RR093081	2	3	1	200	36.1	46.27	4.83	53.46	6.07
RR093081	2	1	2	200	35.7	46.27	5.94	59.05	6.32
RR093081	2	2	2	200	37.0	46.27	5.94	56.45	6.26
RR093081	2	3	2	200	36.1	46.27	5.94	50.73	5.65
RR093081	2	1	3	200	35.7	46.27	41.85	79.81	7.52
RR093081	2	2	3	200	37.0	46.27	41.85	77.37	7.60
RR093081	2	3	3	200	36.1	46.27	41.85	79.47	7.58
RR093082	1	1	1	110	91.5	3.13	1.42	59.65	3.71
RR093082	1	2	1	110	91.8	3.13	1.42	63.18	3.72
RR093082	1	3	1	110	91.9	3.13	1.42	59.12	3.68
RR093082	1	1	2	110	91.5	3.13	5.94	52.27	3.85
RR093082	1	2	2	110	91.8	3.13	5.94	54.91	3.86
RR093082	1	3	2	110	91.9	3.13	5.94	45.47	3.96
RR093082	1	1	3	110	91.5	3.13	170.39	84.95	4.46
RR093082	1	2	3	110	91.8	3.13	170.39	60.10	3.75
RR093082	1	3	3	110	91.9	3.13	170.39	55.78	3.55
RR093082	2	1	1	110	92.7	46.18	3.29	32.49	4.23
RR093082	2	2	1	110	88.8	46.18	3.29	26.82	3.75
RR093082	2	3	1	110	89.8	46.18	3.29	32.69	4.17
RR093082	2	1	2	110	92.7	46.18	6.26	38.40	4.63
RR093082	2	2	2	110	88.8	46.18	6.27	35.43	4.73
RR093082	2	3	2	110	89.8	46.18	6.27	39.19	4.30
RR093082	2	1	3	110	92.7	46.18	41.96	49.57	4.16
RR093082	2	2	3	110	88.8	46.18	41.96	48.23	4.18
RR093082	2	3	3	110	89.8	46.18	42.18	43.69	3.78

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093083	1	1	1	110	82.2	3.12	1.41	56.43	3.43
RR093083	1	2	1	110	82.2	3.12	1.41	62.91	3.77
RR093083	1	3	1	110	84.7	3.12	1.41	63.58	3.70
RR093083	1	1	2	110	82.2	3.12	6.03	53.34	4.00
RR093083	1	2	2	110	82.2	3.12	6.03	61.46	4.27
RR093083	1	3	2	110	84.7	3.12	6.03	54.91	4.14
RR093083	1	1	3	110	82.2	3.12	170.38	58.70	3.61
RR093083	1	2	3	110	82.2	3.12	170.38	72.46	4.00
RR093083	1	3	3	110	84.7	3.12	170.38	60.21	3.61
RR093083	2	1	1	110	84.1	46.17	3.35	31.53	4.07
RR093083	2	2	1	110	84.1	46.17	3.35	28.95	3.88
RR093083	2	3	1	110	85.5	46.17	3.35	36.20	4.39
RR093083	2	1	2	110	84.1	46.17	6.26	41.46	4.33
RR093083	2	2	2	110	84.1	46.17	6.26	38.50	4.00
RR093083	2	3	2	110	85.5	46.17	6.26	40.25	4.09
RR093083	2	1	3	110	84.1	46.17	43.21	51.21	4.46
RR093083	2	2	3	110	84.1	46.17	43.21	55.65	4.64
RR093083	2	3	3	110	85.5	46.17	43.21	52.97	4.84
RR093084	1	1	1	100	93.2	3.08	1.42	71.44	4.43
RR093084	1	2	1	100	94.5	3.08	1.42	66.44	4.00
RR093084	1	3	1	100	96.1	3.08	1.42	76.94	4.35
RR093084	1	1	2	100	93.2	3.08	6.03	58.96	5.19
RR093084	1	2	2	100	94.5	3.08	6.03	52.74	4.62
RR093084	1	3	2	100	96.1	3.08	6.03	62.15	5.16
RR093084	1	1	3	100	93.2	3.08	170.38	57.53	4.09
RR093084	1	2	3	100	94.5	3.08	170.38	56.20	4.17
RR093084	1	3	3	100	96.1	3.08	170.38	67.98	4.43
RR093084	2	1	1	100	95.9	46.13	3.28	25.60	3.96
RR093084	2	2	1	100	95.7	46.13	3.28	31.15	4.15
RR093084	2	3	1	100	96.2	46.13	3.28	28.90	4.53
RR093084	2	1	2	100	95.9	46.13	6.26	36.40	4.44
RR093084	2	2	2	100	95.7	46.13	6.82	40.87	4.97
RR093084	2	3	2	100	96.2	46.13	6.82	42.37	5.40
RR093084	2	1	3	100	95.9	46.13	44.01	51.47	5.64
RR093084	2	2	3	100	95.7	46.13	44.01	52.90	5.85
RR093084	2	3	3	100	96.2	46.13	44.01	47.35	5.29
RR093085	1	1	1	200	52.6	3.18	0.34	16.68	2.89
RR093085	1	2	1	200	53.8	3.18	0.34	22.49	3.28
RR093085	1	3	1	200	52.8	3.18	0.34	15.38	2.85
RR093085	1	1	2	200	52.6	3.18	5.47	17.66	2.96
RR093085	1	2	2	200	53.8	3.18	5.47	21.11	3.21
RR093085	1	3	2	200	52.8	3.18	5.47	17.13	2.98
RR093085	1	1	3	200	52.6	3.18	170.08	20.26	3.47
RR093085	1	2	3	200	53.8	3.18	170.08	20.64	3.39
RR093085	1	3	3	200	52.8	3.18	170.08	21.28	3.45

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093085	2	1	1	200	56.2	46.23	4.10	13.82	3.20
RR093085	2	2	1	200	54.6	46.23	4.10	11.62	2.73
RR093085	2	3	1	200	55.6	46.23	4.10	16.18	3.05
RR093085	2	1	2	200	56.2	46.23	6.04	13.58	2.88
RR093085	2	2	2	200	54.6	46.23	6.04	14.13	2.88
RR093085	2	3	2	200	55.6	46.23	6.09	15.80	3.21
RR093085	2	1	3	200	56.2	46.23	44.01	19.96	3.41
RR093085	2	2	3	200	54.6	46.23	44.02	20.67	1.91
RR093085	2	3	3	200	55.6	46.23	44.01	22.04	3.30
RR093373	1	1	1	200	36.5	3.24	1.08	28.44	4.02
RR093373	1	2	1	200	36.0	3.24	1.08	25.44	3.78
RR093373	1	3	1	200	35.7	3.24	1.08	27.95	3.91
RR093373	1	1	2	200	36.5	3.24	5.87	25.72	4.35
RR093373	1	2	2	200	36.0	3.24	5.87	24.63	4.26
RR093373	1	3	2	200	35.7	3.24	5.87	27.91	4.26
RR093373	1	1	3	200	36.5	3.24	42.02	25.58	4.40
RR093373	1	2	3	200	36.0	3.24	42.02	25.33	4.40
RR093373	1	3	3	200	35.7	3.24	42.02	27.09	4.50
RR093373	2	1	1	200	36.0	37.16	0.18	37.55	5.05
RR093373	2	2	1	200	33.7	37.16	0.18	67.14	6.36
RR093373	2	3	1	200	35.1	37.16	0.17	53.33	5.81
RR093373	2	1	2	200	36.0	37.16	4.38	35.86	3.46
RR093373	2	2	2	200	33.7	37.16	4.38	68.31	4.68
RR093373	2	3	2	200	35.1	37.16	4.38	55.24	4.19
RR093373	2	1	3	200	36.0	37.16	31.20	37.88	4.37
RR093373	2	2	3	200	33.7	37.16	31.20	64.31	5.59
RR093373	2	3	3	200	35.1	37.16	31.20	51.62	5.00
RR093374	1	1	1	150	83.8	3.25	1.79	31.64	3.27
RR093374	1	2	1	150	83.8	3.25	1.79	32.04	3.22
RR093374	1	3	1	150	87.6	3.25	1.79	34.17	3.52
RR093374	1	1	2	150	83.8	3.25	5.90	27.45	3.38
RR093374	1	2	2	150	83.8	3.25	5.90	32.42	3.27
RR093374	1	3	2	150	87.6	3.25	5.90	29.90	3.44
RR093374	1	1	3	150	83.8	3.25	43.34	27.60	3.25
RR093374	1	2	3	150	83.8	3.25	43.34	28.97	3.23
RR093374	1	3	3	150	87.6	3.25	43.34	26.78	3.04
RR093374	2	1	1	150	85.1	37.17	0.89	45.35	3.77
RR093374	2	2	1	150	83.3	37.17	0.89	55.36	4.27
RR093374	2	3	1	150	88.3	37.17	0.89	51.30	3.96
RR093374	2	1	2	150	85.1	37.17	5.02	37.84	3.56
RR093374	2	2	2	150	83.3	37.17	5.02	52.59	4.19
RR093374	2	3	2	150	88.3	37.17	5.02	46.31	3.83
RR093374	2	1	3	150	85.1	37.17	31.20	41.03	3.55
RR093374	2	2	3	150	83.3	37.17	31.20	50.40	3.98
RR093374	2	3	3	150	88.3	37.17	31.20	50.78	4.18

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093375	1	1	1	200	45.9	3.20	1.79	18.39	3.61
RR093375	1	2	1	200	45.6	3.20	1.79	22.38	3.87
RR093375	1	3	1	200	48.1	3.20	1.79	16.82	3.59
RR093375	1	1	2	200	45.9	3.20	5.87	22.22	3.67
RR093375	1	2	2	200	45.6	3.20	5.87	27.14	4.02
RR093375	1	3	2	200	48.1	3.20	5.87	26.18	4.16
RR093375	1	1	3	200	45.9	3.20	42.02	31.66	4.53
RR093375	1	2	3	200	45.6	3.20	42.02	34.59	4.79
RR093375	1	3	3	200	48.1	3.20	42.02	32.12	4.41
RR093375	2	1	1	200	50.3	37.12	0.18	18.06	3.32
RR093375	2	2	1	200	46.5	37.12	0.18	18.18	3.44
RR093375	2	3	1	200	43.4	37.12	0.18	22.08	3.47
RR093375	2	1	2	200	50.3	37.12	4.38	36.00	4.09
RR093375	2	2	2	200	46.5	37.12	4.38	29.70	3.66
RR093375	2	3	2	200	43.4	37.12	4.38	28.68	3.28
RR093375	2	1	3	200	50.3	37.12	31.20	41.55	4.80
RR093375	2	2	3	200	46.5	37.12	31.20	42.05	4.72
RR093375	2	3	3	200	43.4	37.12	31.20	40.22	4.29
RR093376	1	1	1	160	105.6	3.24	1.79	33.97	3.39
RR093376	1	2	1	160	104.3	3.24	1.79	41.58	3.65
RR093376	1	3	1	160	106.6	3.24	1.79	44.37	3.84
RR093376	1	1	2	160	105.6	3.24	5.89	38.46	3.81
RR093376	1	2	2	160	104.3	3.24	5.92	49.24	4.23
RR093376	1	3	2	160	106.6	3.24	6.00	48.98	3.96
RR093376	1	1	3	160	105.6	3.24	43.34	39.81	3.97
RR093376	1	2	3	160	104.3	3.24	43.34	44.75	3.80
RR093376	1	3	3	160	106.6	3.24	43.34	46.09	4.06
RR093376	2	1	1	160	105.4	37.16	0.89	54.32	4.45
RR093376	2	2	1	160	114.1	37.16	0.89	73.76	5.34
RR093376	2	3	1	160	113.1	37.16	0.89	78.41	5.26
RR093376	2	1	2	160	105.4	37.16	5.02	40.85	4.14
RR093376	2	2	2	160	114.1	37.16	5.02	63.17	4.95
RR093376	2	3	2	160	113.1	37.16	5.02	69.44	5.17
RR093376	2	1	3	160	105.4	37.16	31.37	50.06	4.34
RR093376	2	2	3	160	114.1	37.16	31.37	65.40	4.99
RR093376	2	3	3	160	113.1	37.16	31.37	73.50	5.08
RR093377	1	1	1	90	111.2	3.17	1.89	126.39	8.96
RR093377	1	2	1	90	113.4	3.17	1.93	128.66	9.17
RR093377	1	3	1	90	113.7	3.17	1.93	130.03	9.09
RR093377	1	1	2	90	111.2	3.17	5.97	161.39	9.89
RR093377	1	2	2	90	113.4	3.17	5.97	165.23	10.26
RR093377	1	3	2	90	113.7	3.17	5.97	102.94	7.71
RR093377	1	1	3	90	111.2	3.17	43.34	152.07	9.45
RR093377	1	2	3	90	113.4	3.17	43.34	155.88	9.85
RR093377	1	3	3	90	113.7	3.17	44.16	105.86	8.57

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093377	2	1	1	90	116.4	37.09	0.89	108.88	7.96
RR093377	2	2	1	90	114.7	37.09	0.89	75.93	6.82
RR093377	2	3	1	90	119.3	37.09	0.89	58.94	6.77
RR093377	2	1	2	90	116.4	37.09	5.02	165.96	10.64
RR093377	2	2	2	90	114.7	37.09	5.02	118.62	8.23
RR093377	2	3	2	90	119.3	37.09	5.02	103.04	7.96
RR093377	2	1	3	90	116.4	37.09	31.37	201.10	11.00
RR093377	2	2	3	90	114.7	37.09	31.37	158.45	9.68
RR093377	2	3	3	90	119.3	37.09	32.18	146.36	9.92
RR093378	1	1	1	50	85.1	3.24	1.93	54.57	8.09
RR093378	1	2	1	50	87.4	3.24	2.96	51.87	8.39
RR093378	1	3	1	50	88.6	3.24	2.96	63.22	9.60
RR093378	1	1	2	50	85.1	3.24	6.00	42.03	6.91
RR093378	1	2	2	50	87.4	3.24	6.77	47.78	8.04
RR093378	1	3	2	50	88.6	3.24	6.77	44.76	8.69
RR093378	1	1	3	50	85.1	3.24	44.16	45.56	8.70
RR093378	1	2	3	50	87.4	3.24	44.16	42.61	7.93
RR093378	1	3	3	50	88.6	3.24	44.16	36.40	8.12
RR093378	2	1	1	50	86.8	37.16	0.89	47.90	8.18
RR093378	2	2	1	50	87.1	37.16	2.39	29.05	7.34
RR093378	2	3	1	50	92.4	37.16	2.39	68.95	10.23
RR093378	2	1	2	50	86.8	37.16	5.02	62.75	8.25
RR093378	2	2	2	50	87.1	37.16	5.12	27.42	7.24
RR093378	2	3	2	50	92.4	37.16	6.38	79.04	9.98
RR093378	2	1	3	50	86.8	37.16	32.18	90.51	10.81
RR093378	2	2	3	50	87.1	37.16	32.18	48.94	8.32
RR093378	2	3	3	50	92.4	37.16	32.18	99.84	10.36
RR093660	1	1	1	200	51.9	5.31	0.88	60.84	5.08
RR093660	1	2	1	200	54.5	5.31	0.88	71.65	5.85
RR093660	1	3	1	200	49.8	5.31	0.88	51.90	4.68
RR093660	1	1	2	200	51.9	5.31	4.04	61.48	5.11
RR093660	1	2	2	200	54.5	5.31	4.04	68.96	5.74
RR093660	1	3	2	200	49.8	5.31	4.04	53.95	4.76
RR093660	1	1	3	200	51.9	5.31	31.77	66.79	5.49
RR093660	1	2	3	200	54.5	5.31	31.77	63.92	5.62
RR093660	1	3	3	200	49.8	5.31	31.77	57.65	5.09
RR093660	2	1	1	100	22.3	143.13	0.97	53.10	4.59
RR093660	2	2	1	100	22.6	143.13	0.97	54.72	4.56
RR093660	2	3	1	100	23.2	143.13	0.97	54.84	4.61
RR093660	2	1	2	100	22.3	143.13	5.20	57.34	4.16
RR093660	2	2	2	100	22.6	143.13	5.20	64.19	4.47
RR093660	2	3	2	100	23.2	143.13	5.20	61.69	4.33
RR093660	2	1	3	100	22.3	143.13	104.16	56.63	4.51
RR093660	2	2	3	100	22.6	143.13	104.16	62.45	4.82
RR093660	2	3	3	100	23.2	143.13	104.16	59.29	4.69

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093661	1	1	1	50	16.4	5.42	0.88	0.44	2.13
RR093661	1	2	1	50	17.9	5.42	0.88	4.14	2.11
RR093661	1	3	1	50	16.1	5.42	0.88	4.26	1.91
RR093661	1	1	2	50	16.4	5.42	3.22	4.11	1.95
RR093661	1	2	2	50	17.9	5.42	3.22	-1.07	2.08
RR093661	1	3	2	50	16.1	5.42	3.22	3.41	1.98
RR093661	1	1	3	50	16.4	5.42	33.06	12.18	2.64
RR093661	1	2	3	50	17.9	5.42	33.06	4.25	2.12
RR093661	1	3	3	50	16.1	5.42	33.06	6.41	2.15
RR093661	2	1	1	50	15.8	143.23	0.11	-0.95	1.76
RR093661	2	2	1	50	16.8	143.23	0.11	-1.29	1.84
RR093661	2	3	1	50	16.5	143.23	0.11	0.31	1.76
RR093661	2	1	2	50	15.8	143.23	5.20	4.40	1.87
RR093661	2	2	2	50	16.8	143.23	5.20	1.46	1.65
RR093661	2	3	2	50	16.5	143.23	5.20	1.00	1.63
RR093661	2	1	3	50	15.8	143.23	104.46	1.06	1.56
RR093661	2	2	3	50	16.8	143.23	104.46	-0.12	1.65
RR093661	2	3	3	50	16.5	143.23	104.46	2.85	1.80
RR093662	1	1	1	200	63.9	5.13	0.88	31.20	3.77
RR093662	1	2	1	200	64.3	5.13	0.88	33.12	3.62
RR093662	1	3	1	200	62.7	5.13	0.88	35.06	3.67
RR093662	1	1	2	200	63.9	5.13	4.04	52.31	4.74
RR093662	1	2	2	200	64.3	5.13	4.04	52.62	4.77
RR093662	1	3	2	200	62.7	5.13	4.04	51.29	4.60
RR093662	1	1	3	200	63.9	5.13	31.77	67.08	5.28
RR093662	1	2	3	200	64.3	5.13	31.77	68.54	5.14
RR093662	1	3	3	200	62.7	5.13	31.77	73.25	5.17
RR093662	2	1	1	100	30.3	142.94	0.97	25.72	3.36
RR093662	2	2	1	100	31.2	142.94	0.98	22.71	3.21
RR093662	2	3	1	100	30.6	142.94	0.98	26.81	3.33
RR093662	2	1	2	100	30.3	142.94	5.21	46.27	3.94
RR093662	2	2	2	100	31.2	142.94	5.21	47.76	3.88
RR093662	2	3	2	100	30.6	142.94	5.21	48.68	3.83
RR093662	2	1	3	100	30.3	142.94	104.97	60.12	4.48
RR093662	2	2	3	100	31.2	142.94	104.97	62.26	4.79
RR093662	2	3	3	100	30.6	142.94	104.97	64.94	4.88
RR093663	1	1	1	200	89.2	5.18	0.03	30.55	3.36
RR093663	1	2	1	200	92.8	5.18	0.03	34.25	3.78
RR093663	1	3	1	200	88.7	5.18	0.03	27.80	3.16
RR093663	1	1	2	200	89.2	5.18	4.04	32.33	3.59
RR093663	1	2	2	200	92.8	5.18	4.04	31.82	3.35
RR093663	1	3	2	200	88.7	5.18	4.04	30.65	3.25
RR093663	1	1	3	200	89.2	5.18	31.77	33.22	3.64
RR093663	1	2	3	200	92.8	5.18	33.06	36.48	3.82
RR093663	1	3	3	200	88.7	5.18	33.06	30.66	3.33

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RR093663	2	1	1	100	43.3	143.00	0.10	19.41	2.76
RR093663	2	2	1	100	43.8	143.00	0.10	16.11	2.50
RR093663	2	3	1	100	44.7	143.00	0.10	16.53	2.59
RR093663	2	1	2	100	43.3	143.00	4.32	24.09	2.80
RR093663	2	2	2	100	43.8	143.00	4.32	24.16	2.87
RR093663	2	3	2	100	44.7	143.00	4.32	25.50	2.93
RR093663	2	1	3	100	43.3	143.00	104.96	37.38	3.54
RR093663	2	2	3	100	43.8	143.00	104.96	37.48	3.50
RR093663	2	3	3	100	44.7	143.00	104.96	35.25	3.50
RR093664	1	1	1	80	96.8	5.29	0.03	29.46	5.53
RR093664	1	2	1	80	86.0	5.29	0.03	24.49	4.46
RR093664	1	3	1	80	95.1	5.29	0.03	25.61	5.09
RR093664	1	1	2	80	96.8	5.29	3.23	39.47	5.98
RR093664	1	2	2	80	86.0	5.29	3.23	30.96	4.73
RR093664	1	3	2	80	95.1	5.29	3.23	29.36	5.42
RR093664	1	1	3	80	96.8	5.29	33.06	53.06	6.29
RR093664	1	2	3	80	86.0	5.29	33.06	51.72	5.89
RR093664	1	3	3	80	95.1	5.29	33.06	42.71	6.26
RR093664	2	1	1	80	73.8	143.11	0.10	14.50	3.63
RR093664	2	2	1	80	72.0	143.11	0.10	12.54	3.43
RR093664	2	3	1	80	74.1	143.11	0.10	13.06	3.35
RR093664	2	1	2	80	73.8	143.11	4.32	29.44	4.44
RR093664	2	2	2	80	72.0	143.11	4.32	26.00	4.10
RR093664	2	3	2	80	74.1	143.11	4.32	31.38	4.38
RR093664	2	1	3	80	73.8	143.11	104.96	35.15	2.76
RR093664	2	2	3	80	72.0	143.11	104.96	29.10	2.32
RR093664	2	3	3	80	74.1	143.11	105.03	36.51	2.69
RS095390	1	1	1	180	48.3	3.06	0.03	29.19	3.61
RS095390	1	2	1	180	48.3	3.06	0.03	24.70	3.51
RS095390	1	3	1	180	50.0	3.06	0.03	26.83	3.50
RS095390	1	1	2	180	48.3	3.06	3.06	27.84	3.55
RS095390	1	2	2	180	48.3	3.06	3.06	24.34	3.47
RS095390	1	3	2	180	50.0	3.06	3.06	23.60	3.32
RS095390	1	1	3	180	48.3	3.06	33.10	26.45	3.48
RS095390	1	2	3	180	48.3	3.06	33.10	26.85	3.57
RS095390	1	3	3	180	50.0	3.06	33.10	27.34	3.49
RS095390	2	1	1	150	41.0	76.00	0.02	8.33	2.41
RS095390	2	2	1	150	47.1	76.00	0.02	6.86	2.38
RS095390	2	3	1	150	42.3	76.00	0.02	8.47	2.40
RS095390	2	1	2	150	41.0	76.00	3.99	17.68	2.92
RS095390	2	2	2	150	47.1	76.00	3.99	16.45	3.01
RS095390	2	3	2	150	42.3	76.00	3.99	16.54	2.98
RS095390	2	1	3	150	41.0	76.00	35.49	25.85	2.97
RS095390	2	2	3	150	47.1	76.00	35.49	24.97	3.19
RS095390	2	3	3	150	42.3	76.00	35.49	26.37	2.97

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RS095391	1	1	1	180	72.8	3.06	0.03	52.36	4.11
RS095391	1	2	1	180	74.3	3.06	0.03	54.75	4.23
RS095391	1	3	1	180	74.2	3.06	0.03	51.07	4.09
RS095391	1	1	2	180	72.8	3.06	3.06	52.68	4.11
RS095391	1	2	2	180	74.3	3.06	3.06	53.64	4.22
RS095391	1	3	2	180	74.2	3.06	3.06	48.29	4.03
RS095391	1	1	3	180	72.8	3.06	33.10	63.46	4.41
RS095391	1	2	3	180	74.3	3.06	33.10	58.77	4.33
RS095391	1	3	3	180	74.2	3.06	33.10	54.16	4.19
RS095391	2	1	1	150	60.4	76.00	0.39	23.33	3.05
RS095391	2	2	1	150	63.3	76.00	0.39	21.06	2.90
RS095391	2	3	1	150	60.0	76.00	0.39	21.25	2.85
RS095391	2	1	2	150	60.4	76.00	4.07	35.31	3.41
RS095391	2	2	2	150	63.3	76.00	4.07	41.23	3.81
RS095391	2	3	2	150	60.0	76.00	4.07	34.36	3.27
RS095391	2	1	3	150	60.4	76.00	39.27	57.40	4.19
RS095391	2	2	3	150	63.3	76.00	39.27	62.16	4.46
RS095391	2	3	3	150	60.0	76.00	39.27	57.48	4.05
RS095392	1	1	1	180	55.3	3.08	0.03	39.95	4.15
RS095392	1	2	1	180	53.2	3.08	0.03	36.31	3.90
RS095392	1	3	1	180	55.5	3.08	0.03	42.01	4.02
RS095392	1	1	2	180	55.3	3.08	3.06	41.00	4.25
RS095392	1	2	2	180	53.2	3.08	3.06	40.68	4.06
RS095392	1	3	2	180	55.5	3.08	3.06	41.21	4.09
RS095392	1	1	3	180	55.3	3.08	33.10	49.55	4.64
RS095392	1	2	3	180	53.2	3.08	33.10	45.04	4.16
RS095392	1	3	3	180	55.5	3.08	33.10	43.60	4.22
RS095392	2	1	1	150	45.5	76.03	0.40	15.59	2.84
RS095392	2	2	1	150	46.4	76.03	0.40	16.15	3.07
RS095392	2	3	1	150	46.0	76.03	0.44	18.98	3.16
RS095392	2	1	2	150	45.5	76.03	3.99	27.12	3.52
RS095392	2	2	2	150	46.4	76.03	3.99	25.94	3.42
RS095392	2	3	2	150	46.0	76.03	3.99	31.19	3.81
RS095392	2	1	3	150	45.5	76.03	37.43	40.68	4.14
RS095392	2	2	3	150	46.4	76.03	37.43	41.02	4.25
RS095392	2	3	3	150	46.0	76.03	37.43	52.25	4.58
RS095393	1	1	1	180	36.5	3.50	0.03	5.50	2.07
RS095393	1	2	1	180	35.3	3.50	0.03	6.42	2.16
RS095393	1	3	1	180	32.3	3.50	0.03	3.02	1.61
RS095393	1	1	2	180	36.5	3.50	3.00	4.88	2.02
RS095393	1	2	2	180	35.3	3.50	3.00	4.76	2.00
RS095393	1	3	2	180	32.3	3.50	3.00	4.37	1.72
RS095393	1	1	3	180	36.5	3.50	33.50	3.90	2.10
RS095393	1	2	3	180	35.3	3.50	33.50	6.21	2.28
RS095393	1	3	3	180	32.3	3.50	33.50	6.25	2.02

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RS095393	2	1	1	150	29.1	77.12	0.03	2.23	2.16
RS095393	2	2	1	150	27.8	77.12	0.03	0.33	1.89
RS095393	2	3	1	150	26.7	77.12	0.03	1.20	1.88
RS095393	2	1	2	150	29.1	77.12	3.91	2.12	2.14
RS095393	2	2	2	150	27.8	77.12	3.92	2.78	2.15
RS095393	2	3	2	150	26.7	77.12	3.92	1.76	1.76
RS095393	2	1	3	150	29.1	77.12	35.91	5.21	2.28
RS095393	2	2	3	150	27.8	77.12	35.92	6.21	2.20
RS095393	2	3	3	150	26.7	77.12	36.83	4.36	2.12
RS095394	1	1	1	180	77.2	2.49	0.03	95.42	5.20
RS095394	1	2	1	180	73.2	2.49	0.03	87.60	4.89
RS095394	1	3	1	180	67.5	2.49	0.03	83.65	4.65
RS095394	1	1	2	180	77.2	2.49	3.50	87.93	5.02
RS095394	1	2	2	180	73.2	2.49	3.50	90.26	5.00
RS095394	1	3	2	180	67.5	2.49	3.50	87.48	4.90
RS095394	1	1	3	180	77.2	2.49	33.50	73.68	4.71
RS095394	1	2	3	180	73.2	2.49	33.50	79.46	4.87
RS095394	1	3	3	180	67.5	2.49	33.50	71.61	4.53
RS095394	2	1	1	150	60.1	76.11	0.88	68.55	4.44
RS095394	2	2	1	150	64.1	76.11	0.88	64.71	4.49
RS095394	2	3	1	150	64.6	76.11	0.88	69.01	4.70
RS095394	2	1	2	150	60.1	76.11	4.09	70.00	4.48
RS095394	2	2	2	150	64.1	76.11	4.09	69.60	4.75
RS095394	2	3	2	150	64.6	76.11	4.09	63.91	4.39
RS095394	2	1	3	150	60.1	76.11	38.19	61.91	4.26
RS095394	2	2	3	150	64.1	76.11	38.19	59.01	4.39
RS095394	2	3	3	150	64.6	76.11	38.19	58.82	4.45
RS095395	1	1	1	150	57.3	3.91	0.03	29.67	3.44
RS095395	1	2	1	150	55.8	3.91	0.03	26.12	3.27
RS095395	1	3	1	150	56.0	3.91	0.03	21.30	3.07
RS095395	1	1	2	150	57.3	3.91	3.00	39.51	3.79
RS095395	1	2	2	150	55.8	3.91	3.00	37.25	3.74
RS095395	1	3	2	150	56.0	3.91	3.00	37.36	3.68
RS095395	1	1	3	150	57.3	3.91	33.50	47.72	4.25
RS095395	1	2	3	150	55.8	3.91	33.50	48.52	4.25
RS095395	1	3	3	150	56.0	3.91	33.50	46.31	3.99
RS095395	2	1	1	150	56.4	77.53	0.19	27.08	3.54
RS095395	2	2	1	150	51.5	77.53	0.19	22.14	3.16
RS095395	2	3	1	150	50.6	77.53	0.19	23.30	3.15
RS095395	2	1	2	150	56.4	77.53	3.22	40.93	4.10
RS095395	2	2	2	150	51.5	77.53	3.22	35.09	3.63
RS095395	2	3	2	150	50.6	77.53	3.22	37.92	3.85
RS095395	2	1	3	150	56.4	77.53	38.19	65.06	4.75
RS095395	2	2	3	150	51.5	77.53	38.19	58.58	4.39
RS095395	2	3	3	150	50.6	77.53	38.19	63.55	4.29

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RS095396	1	1	1	180	40.8	2.42	0.12	76.18	5.63
RS095396	1	2	1	180	39.5	2.42	0.12	77.23	5.68
RS095396	1	3	1	180	42.9	2.42	0.12	82.27	6.03
RS095396	1	1	2	180	40.8	2.42	3.00	69.42	5.18
RS095396	1	2	2	180	39.5	2.42	3.00	77.38	5.42
RS095396	1	3	2	180	42.9	2.42	3.00	74.89	5.51
RS095396	1	1	3	180	40.8	2.42	33.50	70.69	5.28
RS095396	1	2	3	180	39.5	2.42	33.50	69.89	5.21
RS095396	1	3	3	180	42.9	2.42	33.50	76.74	5.56
RS095396	2	1	1	150	33.0	76.04	0.03	67.94	5.74
RS095396	2	2	1	150	30.5	76.04	0.03	67.47	5.57
RS095396	2	3	1	150	32.3	76.04	0.03	71.56	5.86
RS095396	2	1	2	150	33.0	76.04	3.92	68.29	5.75
RS095396	2	2	2	150	30.5	76.04	3.92	65.91	5.49
RS095396	2	3	2	150	32.3	76.04	3.92	62.40	5.52
RS095396	2	1	3	150	33.0	76.04	36.84	76.96	5.64
RS095396	2	2	3	150	30.5	76.04	36.84	67.88	5.06
RS095396	2	3	3	150	32.3	76.04	36.84	70.81	5.32
RS095397	1	1	1	100	91.5	4.26	0.26	32.39	4.00
RS095397	1	2	1	100	90.7	4.26	0.26	27.66	3.83
RS095397	1	2	1	100	90.7	4.26	0.26	27.66	3.83
RS095397	1	1	2	100	91.5	4.26	2.84	32.84	4.87
RS095397	1	2	2	100	90.7	4.26	2.91	24.84	4.60
RS095397	1	3	2	100	89.6	4.26	2.91	22.59	4.43
RS095397	1	1	3	100	91.5	4.26	32.97	29.25	4.47
RS095397	1	2	3	100	90.7	4.26	32.97	29.49	4.74
RS095397	1	3	3	100	89.6	4.26	33.01	29.86	4.65
RS095397	2	1	1	100	91.0	76.46	0.03	25.55	2.99
RS095397	2	2	1	100	92.1	76.46	0.03	28.89	3.12
RS095397	2	3	1	100	91.0	76.46	0.04	27.94	3.05
RS095397	2	1	2	100	91.0	76.46	3.89	22.83	2.48
RS095397	2	2	2	100	92.1	76.46	3.89	24.82	2.50
RS095397	2	3	2	100	91.0	76.46	3.89	27.57	2.54
RS095397	2	1	3	100	91.0	76.46	39.48	26.77	2.49
RS095397	2	2	3	100	92.1	76.46	39.48	24.44	2.32
RS095397	2	3	3	100	91.0	76.46	39.48	27.12	2.50
RS095398	1	1	1	150	94.4	4.05	0.26	22.80	2.70
RS095398	1	2	1	150	90.1	4.05	0.26	20.65	2.62
RS095398	1	3	1	150	89.1	4.05	0.26	24.53	2.71
RS095398	1	1	2	150	94.4	4.05	2.91	19.08	3.23
RS095398	1	2	2	150	90.1	4.05	3.02	20.11	3.15
RS095398	1	3	2	150	89.1	4.05	3.02	19.84	3.09
RS095398	1	1	3	150	94.4	4.05	33.01	20.03	3.20
RS095398	1	2	3	150	90.1	4.05	33.01	22.49	2.96
RS095398	1	3	3	150	89.1	4.05	33.70	23.76	3.22

Table M.1 (Continued)
Gross alpha-particle activity data for sample

Sample no.	Prep. no.	Rep. No.	Count No.	Vol. (mL)	Mass (mg)	T_1 (d)	T_2 (d)	GAA (pCi/L)	GAA error (pCi/L)
RS095398	2	1	1	150	104.1	76.25	0.67	16.84	2.66
RS095398	2	2	1	150	107.9	76.25	0.67	14.95	2.44
RS095398	2	3	1	150	94.7	76.25	0.67	13.84	2.45
RS095398	2	1	2	150	104.1	76.25	3.90	19.42	2.65
RS095398	2	2	2	150	107.9	76.25	3.90	15.46	2.78
RS095398	2	3	2	150	94.7	76.25	3.90	19.11	2.53
RS095398	2	1	3	150	104.1	76.25	39.48	26.49	3.06
RS095398	2	2	3	150	107.9	76.25	39.48	20.42	2.74
RS095398	2	3	3	150	94.7	76.25	39.48	22.83	2.59
RS095399	1	1	1	130	77.2	5.67	0.04	56.09	4.32
RS095399	1	2	1	130	73.1	5.67	0.04	56.09	4.32
RS095399	1	3	1	130	56.1	5.67	0.04	35.38	2.99
RS095399	1	1	2	130	77.2	5.67	4.09	60.92	4.60
RS095399	1	2	2	130	73.1	5.67	4.09	64.75	4.42
RS095399	1	3	2	130	56.1	5.67	4.09	40.61	3.18
RS095399	1	1	3	130	77.2	5.67	40.48	61.15	4.44
RS095399	1	2	3	130	73.1	5.67	40.48	59.65	4.37
RS095399	1	3	3	130	56.1	5.67	40.48	45.25	3.22
RS095399	2	1	1	100	62.6	72.35	0.18	53.62	3.59
RS095399	2	2	1	100	62.9	72.35	0.18	52.16	3.64
RS095399	2	3	1	100	52.0	72.35	0.18	41.43	2.85
RS095399	2	1	2	100	62.6	72.35	2.97	51.64	3.62
RS095399	2	2	2	100	62.9	72.35	2.97	55.74	3.54
RS095399	2	3	2	100	52.0	72.35	2.97	40.70	2.97
RS095399	2	1	3	100	62.6	72.35	35.95	58.23	4.17
RS095399	2	2	3	100	62.9	72.35	35.95	62.57	4.32
RS095399	2	3	3	100	52.0	72.35	35.95	53.13	3.55
RS095400	1	1	1	130	71.2	5.70	0.04	107.54	5.35
RS095400	1	2	1	130	56.7	5.70	0.04	98.17	4.76
RS095400	1	3	1	130	72.4	5.70	0.04	118.07	5.89
RS095400	1	1	2	130	71.2	5.70	5.02	107.87	5.56
RS095400	1	2	2	130	56.7	5.70	5.02	90.99	4.44
RS095400	1	3	2	130	72.4	5.70	5.02	115.59	5.57
RS095400	1	1	3	130	71.2	5.70	40.48	97.49	5.08
RS095400	1	2	3	130	56.7	5.70	40.48	86.70	4.43
RS095400	1	3	3	130	72.4	5.70	40.48	104.70	5.54
RS095400	2	1	1	100	55.4	72.38	0.18	84.11	4.52
RS095400	2	2	1	100	50.4	72.38	0.18	84.95	4.39
RS095400	2	3	1	100	56.0	72.38	0.18	88.99	4.78
RS095400	2	1	2	100	55.4	72.38	2.97	84.03	4.68
RS095400	2	2	2	100	50.4	72.38	2.97	79.79	4.19
RS095400	2	3	2	100	56.0	72.38	2.97	88.84	4.62
RS095400	2	1	3	100	55.4	72.38	35.95	85.62	4.54
RS095400	2	2	3	100	50.4	72.38	35.95	93.90	4.61
RS095400	2	3	3	100	56.0	72.38	35.95	99.06	5.01

APPENDIX N
GROSS RADIUM ACTIVITY DATA

Table N.1 gives the gross radium activities (GRA) for the 79 samples in the study. The first column (Sample no.) gives the sample number. The second column (Prep. no.) indicates whether the GAA is from the first or second preparation. Each sample was counted on the gas proportional counter three times. The third column (Count no.) indicates whether it is the first, second, or third count. The fourth column (Mass) gives the residue mass. The fifth column gives the time, T_1, between sample collection and preparation. The sixth column gives the time, T_2, between sample preparation and analysis. The seventh column (GRA) gives the gross radium activity of the sample and the eighth column (GRA error) gives the counting error in the GRA.

Table N.1
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ091434	1	1	19.5	1.08	0.22	68.29	4.09
RQ091434	1	2	19.5	1.08	3.01	34.17	2.03
RQ091434	1	3	19.5	1.08	7.84	21.09	2.16
RQ091434	2	1	17	37	0.35	12.94	1.82
RQ091434	2	2	17	37	6.86	15.11	1.19
RQ091434	2	3	17	37	39.05	15.97	1.08
RQ091435	1	1	16.7	1.08	0.22	25.96	2.59
RQ091435	1	2	16.7	1.08	3.01	12.1	1.24
RQ091435	1	3	16.7	1.08	7.84	9.72	1.56
RQ091435	2	1	15.3	37	0.35	5.24	1.28
RQ091435	2	2	15.3	37	6.86	4.77	0.7
RQ091435	2	3	15.3	37	39.05	4.84	0.62
RQ091436	1	1	20.8	1.25	0.22	21.88	2.16
RQ091436	1	2	20.8	1.25	3.01	2.51	0.23
RQ091436	1	3	20.8	1.25	7.84	1.93	0.28
RQ091436	2	1	19.8	37.17	0.35	1.56	0.26
RQ091436	2	2	19.8	37.17	6.86	1.42	0.15
RQ091436	2	3	19.8	37.17	39.05	1.46	0.14
RQ091437	1	1	23.3	1.23	0.22	22.75	2.14
RQ091437	1	2	23.3	1.23	3.01	11.06	1.05
RQ091437	1	3	23.3	1.23	7.84	7.49	1.22
RQ091437	2	1	22.9	37.15	0.35	5.94	1.15
RQ091437	2	2	22.9	37.15	6.86	5.4	0.63
RQ091437	2	3	22.9	37.15	39.05	5.97	0.58
RQ091438	1	1	23.1	1.29	0.22	45.41	3.05
RQ091438	1	2	23.1	1.29	3.01	18.72	1.37
RQ091438	1	3	23.1	1.29	7.84	7.28	1.18
RQ091438	2	1	23.4	37.21	0.35	4.25	0.94
RQ091438	2	2	23.4	37.21	6.86	3.65	0.51
RQ091438	2	3	23.4	37.21	39.05	4.72	0.51

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ091439	1	1	20	1.15	0.22	12.25	1.69
RQ091439	1	2	20	1.15	3.01	6.64	0.87
RQ091439	1	3	20	1.15	7.84	4.38	1.01
RQ091439	2	1	20.6	37.07	0.35	4.88	1.1
RQ091439	2	2	20.6	37.07	6.86	2.96	0.5
RQ091439	2	3	20.6	37.07	39.05	3.3	0.46
RQ091440	1	1	21.6	1.19	0.22	4.04	0.96
RQ091440	1	2	21.6	1.19	3.01	2.25	0.5
RQ091440	1	3	21.6	1.19	7.84	1.6	0.6
RQ091440	2	1	13.2	37.11	0.35	0.66	0.73
RQ091440	2	2	13.2	37.11	6.86	0.3	0.28
RQ091440	2	3	13.2	37.11	39.05	0.17	0.21
RQ091441	1	1	18.5	1.27	0.22	15.72	1.92
RQ091441	1	2	18.5	1.27	3.01	7.52	0.94
RQ091441	1	3	18.5	1.27	7.84	5.36	1.12
RQ091441	2	1	18.9	37.19	0.35	5.33	1.13
RQ091441	2	2	18.9	37.19	6.86	4.37	0.6
RQ091441	2	3	18.9	37.19	39.05	4.12	0.52
RQ091442	1	1	22.6	1.32	0.22	17.93	1.93
RQ091442	1	2	22.6	1.32	3.01	10.19	1.01
RQ091442	1	3	22.6	1.32	7.84	6.07	1.12
RQ091442	2	1	26.7	37.24	0.35	5.34	1.02
RQ091442	2	2	26.7	37.24	6.86	4.68	0.56
RQ091442	2	3	26.7	37.24	39.05	5.75	0.54
RQ091444	1	1	19	1.2	1.12	5.03	1.26
RQ091444	1	2	19	1.2	3.01	3.55	0.74
RQ091444	1	3	19	1.2	9.03	3.91	1
RQ091444	2	1	25.4	37.12	0.35	2.47	0.76
RQ091444	2	2	25.4	37.12	6.86	2.42	0.41
RQ091444	2	3	25.4	37.12	39.05	2.7	0.38
RQ091713	1	1	22.4	2.24	0.35	14.25	1.65
RQ091713	1	2	22.4	2.24	6.86	5.03	0.6
RQ091713	1	3	22.4	2.24	39.05	4.12	0.48
RQ091713	2	1	17	37.24	0.31	2.54	1.04
RQ091713	2	2	17	37.24	6.01	3.42	0.61
RQ091713	2	3	17	37.24	42.14	3.55	0.52
RQ091720	1	1	24.8	2.23	0.35	33.53	2.47
RQ091720	1	2	24.8	2.23	6.86	10.13	0.83
RQ091720	1	3	24.8	2.23	39.05	7.14	0.62
RQ091720	2	1	20.3	37.22	0.31	5.49	1.14
RQ091720	2	2	20.3	37.22	6.01	6	0.7
RQ091720	2	3	20.3	37.22	42.14	5.75	0.59
RQ091721	1	1	23.9	2.08	0.82	7.52	1.11
RQ091721	1	2	23.9	2.08	7.11	5.17	0.6

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ091721	1	3	23.9	2.08	39.35	4.54	0.5
RQ091721	2	1	17.7	37.07	0.31	4.57	1.13
RQ091721	2	2	17.7	37.07	6.01	4.51	0.65
RQ091721	2	3	17.7	37.07	42.14	4.87	0.58
RQ091722	1	1	14.8	2.14	0.82	53.7	3.54
RQ091722	1	2	14.8	2.14	7.11	34.38	1.93
RQ091722	1	3	14.8	2.14	39.35	32.27	1.69
RQ091722	2	1	22.7	37.13	0.31	35.82	2.67
RQ091722	2	2	22.7	37.13	6.01	34.23	1.74
RQ091722	2	3	22.7	37.13	42.14	35.46	1.59
RQ091723	1	1	15.2	2.01	0.82	16.41	1.9
RQ091723	1	2	15.2	2.01	7.11	4.22	0.66
RQ091723	1	3	15.2	2.01	39.35	2.26	0.44
RQ091723	2	1	16.2	37	0.31	2.25	0.92
RQ091723	2	2	16.2	37	6.01	1.3	0.41
RQ091723	2	3	16.2	37	42.14	1.7	0.38
RQ091724	1	1	12.7	2.02	0.82	14.29	2
RQ091724	1	2	12.7	2.02	7.11	2.88	0.65
RQ091724	1	3	12.7	2.02	39.35	1.57	0.46
RQ091724	2	1	25.7	37.02	0.31	2.21	0.76
RQ091724	2	2	25.7	37.02	6.01	1.95	0.4
RQ091724	2	3	25.7	37.02	42.14	1.46	0.29
RQ091725	1	1	16.2	2.08	0.82	8.04	1.32
RQ091725	1	2	16.2	2.08	7.11	4.18	0.63
RQ091725	1	3	16.2	2.08	39.35	3.47	0.51
RQ091725	2	1	20.2	37.07	0.31	4.1	0.97
RQ091725	2	2	20.2	37.07	6.01	3.43	0.53
RQ091725	2	3	20.2	37.07	42.14	3.72	0.47
RQ091726	1	1	22.1	2.08	0.82	9.08	1.24
RQ091726	1	2	22.1	2.08	7.11	5.01	0.61
RQ091726	1	3	22.1	2.08	39.35	4.61	0.52
RQ091726	2	1	24.2	37.07	0.31	3.89	0.89
RQ091726	2	2	24.2	37.07	6.01	4.01	0.53
RQ091726	2	3	24.2	37.07	42.14	3.96	0.46
RQ091751	1	1	18.8	1.08	0.82	32.46	2.45
RQ091751	1	2	18.8	1.08	7.11	7.4	0.77
RQ091751	1	3	18.8	1.08	39.35	5.39	0.59
RQ091751	2	1	21.6	36.07	0.31	5.35	1.15
RQ091751	2	2	21.6	36.07	6.01	4.69	0.63
RQ091751	2	3	21.6	36.07	42.14	5.18	0.56
RQ091992	1	1	18.9	2.09	0.31	0.15	0.6
RQ091992	1	2	18.9	2.09	6.01	0.2	0.25
RQ091992	1	3	18.9	2.09	42.14	0.16	0.2
RQ091992	2	1	17.9	37.14	5.38	0.14	0.31

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ091992	2	2	17.9	37.14	14.34	0.1	0.23
RQ091992	2	3	17.9	37.14	40.04	0.19	0.23
RQ091993	1	1	22.3	2.12	0.31	3.59	0.91
RQ091993	1	2	22.3	2.12	6.01	0.82	0.3
RQ091993	1	3	22.3	2.12	42.14	0.54	0.21
RQ091993	2	1	25.8	37.17	5.38	0.4	0.24
RQ091993	2	2	25.8	37.17	14.34	0.32	0.18
RQ091993	2	3	25.8	37.17	40.04	0.24	0.19
RQ091994	1	1	21.6	2.14	0.31	2.94	0.91
RQ091994	1	2	21.6	2.14	6.01	0.99	0.34
RQ091994	1	3	21.6	2.14	42.14	0.31	0.2
RQ091994	2	1	25.7	37.19	5.38	0.67	0.26
RQ091994	2	2	25.7	37.19	14.34	0.61	0.21
RQ091994	2	3	25.7	37.19	40.04	0.35	0.19
RQ091995	1	1	14.7	2.02	0.52	18.8	2.23
RQ091995	1	2	14.7	2.02	6.23	5.68	0.84
RQ091995	1	3	14.7	2.02	42.35	2.38	0.48
RQ091995	2	1	21	37.07	5.38	3.59	0.58
RQ091995	2	2	21	37.07	14.34	3.38	0.48
RQ091995	2	3	21	37.07	40.04	3.41	0.47
RQ091996	1	1	14.8	2.08	0.52	24.09	2.46
RQ091996	1	2	14.8	2.08	6.23	12.1	1.17
RQ091996	1	3	14.8	2.08	42.35	8.91	0.84
RQ091996	2	1	21.5	37.13	5.38	9.83	0.89
RQ091996	2	2	21.5	37.13	14.34	9.22	0.75
RQ091996	2	3	21.5	37.13	40.04	10.1	0.78
RQ091997	1	1	17.7	2.07	0.52	11.94	1.62
RQ091997	1	2	17.7	2.07	6.23	10.85	1.02
RQ091997	1	3	17.7	2.07	42.35	9.21	0.79
RQ091997	2	1	19.9	37.12	5.38	8.75	0.87
RQ091997	2	2	19.9	37.12	14.34	8.07	0.73
RQ091997	2	3	19.9	37.12	40.04	8.84	0.75
RQ091998	1	1	23.2	2.13	0.52	9.99	1.36
RQ091998	1	2	23.2	2.13	6.23	5.3	0.66
RQ091998	1	3	23.2	2.13	42.35	4.47	0.51
RQ091998	2	1	28.1	37.18	5.38	4.39	0.53
RQ091998	2	2	28.1	37.18	14.34	4.1	0.45
RQ091998	2	3	28.1	37.18	40.04	4.59	0.47
RQ091999	1	1	28.1	2.1	0.52	17.55	1.62
RQ091999	1	2	28.1	2.1	6.23	9.81	0.82
RQ091999	1	3	28.1	2.1	42.35	6.53	0.56
RQ091999	2	1	25.9	37.15	5.38	5.79	0.63
RQ091999	2	2	25.9	37.15	14.34	5.55	0.54
RQ091999	2	3	25.9	37.15	40.04	5.94	0.56

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ092000	1	1	17.7	2.18	0.52	21.84	2.19
RQ092000	1	2	17.7	2.18	6.23	7.09	0.84
RQ092000	1	3	17.7	2.18	42.35	5.05	0.6
RQ092000	2	1	25.5	37.23	5.38	4.99	0.61
RQ092000	2	2	25.5	37.23	14.34	4.57	0.51
RQ092000	2	3	25.5	37.23	40.04	4.91	0.51
RQ092001	1	1	25.8	2.24	0.52	30.36	2.22
RQ092001	1	2	25.8	2.24	6.23	12.24	0.94
RQ092001	1	3	25.8	2.24	42.35	9.58	0.7
RQ092001	2	1	21.9	37.29	5.38	9	0.85
RQ092001	2	2	21.9	37.29	14.34	8.26	0.71
RQ092001	2	3	21.9	37.29	40.04	8.97	0.73
RQ092029	1	1	26.1	1.17	0.52	0.33	0.41
RQ092029	1	2	26.1	1.17	6.23	0.13	0.18
RQ092029	1	3	26.1	1.17	42.35	0.08	0.13
RQ092029	2	1	14.2	36.23	5.38	0.56	0.37
RQ092029	2	2	14.2	36.23	14.34	0.29	0.26
RQ092029	2	3	14.2	36.23	40.04	0.23	0.28
RQ092250	1	1	24.1	2.25	5.38	0.56	0.29
RQ092250	1	2	24.1	2.25	14.34	0.34	0.2
RQ092250	1	3	24.1	2.25	40.04	0.31	0.2
RQ092250	2	1	23.7	37.18	0.34	0.67	0.78
RQ092250	2	2	23.7	37.18	4.38	0.28	0.28
RQ092250	2	3	23.7	37.18	43.41	0.22	0.19
RQ092251	1	1	21.2	2.23	6.25	4.11	0.58
RQ092251	1	2	21.2	2.23	16.08	3.24	0.47
RQ092251	1	3	21.2	2.23	40.26	3.33	0.46
RQ092251	2	1	13.3	37.16	0.34	2.2	1.3
RQ092251	2	2	13.3	37.16	4.38	3.47	0.72
RQ092251	2	3	13.3	37.16	43.41	2.65	0.51
RQ092252	1	1	23.7	2.19	6.25	7.67	0.73
RQ092252	1	2	23.7	2.19	16.08	7.66	0.66
RQ092252	1	3	23.7	2.19	40.26	7.74	0.66
RQ092252	2	1	26.3	37.13	0.34	8.78	1.5
RQ092252	2	2	26.3	37.13	4.38	9.44	0.84
RQ092252	2	3	26.3	37.13	43.41	9.61	0.7
RQ092253	1	1	24	2.25	6.25	0.41	0.24
RQ092253	1	2	24	2.25	16.08	0.24	0.17
RQ092253	1	3	24	2.25	40.26	0.07	0.17
RQ092253	2	1	24.5	37.18	0.34	0.87	0.8
RQ092253	2	2	24.5	37.18	4.38	0.69	0.33
RQ092253	2	3	24.5	37.18	43.41	0.46	0.22
RQ092254	1	1	24.5	2.15	6.25	0.32	0.25
RQ092254	1	2	24.5	2.15	16.08	0.25	0.2

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ092254	1	3	24.5	2.15	40.26	0.58	0.23
RQ092254	2	1	24.7	37.09	0.34	-0.01	0.5
RQ092254	2	2	24.7	37.09	4.38	0.3	0.24
RQ092254	2	3	24.7	37.09	43.41	0.26	0.16
RQ092255	1	1	25.6	2.22	6.25	4.22	0.53
RQ092255	1	2	25.6	2.22	16.08	3.56	0.44
RQ092255	1	3	25.6	2.22	40.26	3.1	0.41
RQ092255	2	1	19.1	37.15	0.48	7.51	1.87
RQ092255	2	2	19.1	37.15	4.39	3.42	0.61
RQ092255	2	3	19.1	37.15	43.41	3.06	0.46
RQ092256	1	1	14.8	2.25	6.25	3.06	0.62
RQ092256	1	2	14.8	2.25	16.08	2.51	0.5
RQ092256	1	3	14.8	2.25	40.26	2.67	0.5
RQ092256	2	1	12.7	37.18	0.34	8.86	2.07
RQ092256	2	2	12.7	37.18	4.39	3.96	0.76
RQ092256	2	3	12.7	37.18	43.41	2.83	0.52
RQ092257	1	1	16.5	2.27	6.25	3.18	0.55
RQ092257	1	2	16.5	2.27	16.08	2.96	0.48
RQ092257	1	3	16.5	2.27	40.26	3.06	0.5
RQ092257	2	1	14.3	37.2	0.34	8.75	1.96
RQ092257	2	2	14.3	37.2	4.39	3.91	0.72
RQ092257	2	3	14.3	37.2	43.41	2.85	0.75
RQ092258	1	1	—	—	—	—	—
RQ092258	1	2	—	—	—	—	—
RQ092258	1	3	—	—	—	—	—
RQ092258	2	1	12.4	37.1	0.34	4.68	1.84
RQ092258	2	2	12.4	37.1	4.39	5.52	0.95
RQ092258	2	3	12.4	37.1	43.41	5.81	0.76
RQ092847	1	1	16	2.02	0.34	0.4	0.88
RQ092847	1	2	16	2.02	4.39	0.41	0.36
RQ092847	1	3	16	2.02	43.41	0.19	0.22
RQ092847	2	1	15.3	37.05	0.18	0.6	0.93
RQ092847	2	2	15.3	37.05	4.14	0.62	0.47
RQ092847	2	3	15.3	37.05			
RQ092849	1	1	15.5	2.12	0.34	9.09	2.00
RQ092849	1	2	15.5	2.12	4.39	4.1	0.74
RQ092849	1	3	15.5	2.12	43.41	2.54	0.47
RQ092849	2	1	13.4	37.16	0.18	3.7	1.28
RQ092849	2	2	13.4	37.16	4.14	3.31	0.71
RQ092849	2	3	13.4	37.16	35.86	2.75	0.51
RQ092850	1	1	14.5	2.18	0.49	0.49	0.85
RQ092850	1	2	14.5	2.18	4.88	0.46	0.42
RQ092850	1	3	14.5	2.18	43.93	-0.14	0.22
RQ092850	2	1	24.8	37.21	0.18	1.35	0.74

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RQ092850	2	2	24.8	37.21	4.14	0.53	0.27
RQ092850	2	3	24.8	37.21	35.86	0.41	0.19
RQ092851	1	1	15.3	2.2	0.49	0.38	0.68
RQ092851	1	2	15.3	2.2	4.88	0.3	0.33
RQ092851	1	3	15.3	2.2	43.93	0.36	0.25
RQ092851	2	1	25.2	37.23	0.18	0.39	0.51
RQ092851	2	2	25.2	37.23	4.14	0.41	0.25
RQ092851	2	3	25.2	37.23	35.86	0.04	0.15
RQ092852	1	1	17.2	1.91	0.49	2.18	0.85
RQ092852	1	2	17.2	1.91	4.88	0.72	0.35
RQ092852	1	3	17.2	1.91	43.93	0.83	0.28
RQ092852	2	1	25.1	36.95	0.18	1.26	0.7
RQ092852	2	2	25.1	36.95	4.14	0.59	0.3
RQ092852	2	3	25.1	36.95	35.86	0.62	0.19
RQ092853	1	1	14.2	1.94	0.49	28.72	2.79
RQ092853	1	2	14.2	1.94	4.88	16.55	1.42
RQ092853	1	3	14.2	1.94	43.93	14.07	1.09
RQ092853	2	1	17.7	36.98	0.18	17.37	2.06
RQ092853	2	2	17.7	36.98	4.14	13.22	1.18
RQ092853	2	3	17.7	36.98	35.86	14.9	1.02
RQ092854	1	1	26.5	2.29	0.49	12.03	1.37
RQ092854	1	2	26.5	2.29	4.88	2.36	0.42
RQ092854	1	3	26.5	2.29	43.93	0.77	0.22
RQ092854	2	1	21.3	37.32	0.18	1.61	0.73
RQ092854	2	2	21.3	37.32	4.14	1.07	0.36
RQ092854	2	3	21.3	37.32	35.87	0.64	0.25
RQ092855	1	1	25.3	2.18	0.49	0.91	0.49
RQ092855	1	2	25.3	2.18	4.88	0.78	0.3
RQ092855	1	3	25.3	2.18	43.93	0.29	0.19
RQ092855	2	1	25.2	37.22	0.18	0.33	0.62
RQ092855	2	2	25.2	37.22	4.14	0.32	0.28
RQ092855	2	3	25.2	37.22	35.87	0.37	0.19
RQ092856	1	1	22.3	2.16	0.49	1.03	0.57
RQ092856	1	2	22.3	2.16	4.88	0.35	0.23
RQ092856	1	3	22.3	2.16	43.93	0.23	0.15
RQ092856	2	1	23.6	37.2	0.18	1.28	0.69
RQ092856	2	2	23.6	37.2	4.14	0.14	0.24
RQ092856	2	3	23.6	37.2	35.87	0.15	0.15
RR093078	1	1	15.3	2.14	0.18	1.76	0.95
RR093078	1	2	15.3	2.14	4.14	0.8	0.45
RR093078	1	3	15.3	2.14	35.87	0.33	0.27
RR093078	2	1	19.2	44.11	0.94	0.56	0.59
RR093078	2	2	19.2	44.11	4.85	0.55	0.35
RR093078	2	3	19.2	44.11	30.25	0.7	0.28

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RR093079	1	1	17.4	2.18	0.18	10.43	1.7
RR093079	1	2	17.4	2.18	4.35	7.16	0.89
RR093079	1	3	17.4	2.18	36.08	7.51	0.73
RR093079	2	1	14.3	44.15	0.94	8.64	1.43
RR093079	2	2	14.3	44.15	4.85	7.02	0.92
RR093079	2	3	14.3	44.15	30.25	8.16	0.82
RR093080	1	1	17.2	2.27	0.39	7.05	1.4
RR093080	1	2	17.2	2.27	4.35	2.69	0.57
RR093080	1	3	17.2	2.27	36.08	1.76	0.37
RR093080	2	1	17.7	44.24	0.94	1.74	0.7
RR093080	2	2	17.7	44.24	4.85	1.75	0.46
RR093080	2	3	17.7	44.24	30.25	1.4	0.33
RR093081	1	1	17.7	2.28	0.39	83.61	4.58
RR093081	1	2	17.7	2.28	4.35	26.45	1.7
RR093081	1	3	17.7	2.28	36.08	9.97	0.83
RR093081	2	1	17.6	44.25	0.94	12.44	1.52
RR093081	2	2	17.6	44.25	4.85	9.83	1
RR093081	2	3	17.6	44.25	30.25	10.3	0.84
RR093082	1	1	24.5	2.2	0.39	24.3	2.07
RR093082	1	2	24.5	2.2	4.35	9.23	0.85
RR093082	1	3	24.5	2.2	36.08	5.38	0.53
RR093082	2	1	20.5	44.16	0.94	4.99	0.97
RR093082	2	2	20.5	44.16	4.85	4.27	0.61
RR093082	2	3	20.5	44.16	30.25	4.79	0.54
RR093083	1	1	21.4	2.17	0.39	26.46	2.29
RR093083	1	2	21.4	2.17	4.35	10.17	0.96
RR093083	1	3	21.4	2.17	36.08	5.92	0.59
RR093083	2	1	25	44.14	0.94	5.95	0.91
RR093083	2	2	25	44.14	4.86	6.16	0.67
RR093083	2	3	25	44.14	30.25	5.94	0.55
RR093084	1	1	21.1	2.14	0.39	27.51	2.33
RR093084	1	2	21.1	2.14	4.35	10.06	0.94
RR093084	1	3	21.1	2.14	36.08	4.96	0.53
RR093084	2	1	24.6	44.11	0.94	5.05	0.87
RR093084	2	2	24.6	44.11	4.86	4.87	0.62
RR093084	2	3	24.6	44.11	30.25	5.61	0.54
RR093085	1	1	14.8	2.24	0.39	8.2	1.58
RR093085	1	2	14.8	2.24	4.35	4.08	0.72
RR093085	1	3	14.8	2.24	36.08	2.98	0.5
RR093085	2	1	26.4	44.21	0.94	2.29	0.66
RR093085	2	2	26.4	44.21	4.86	2.7	0.45
RR093085	2	3	26.4	44.21	30.25	3.04	0.4
RR093373	1	1	15.5	2.18	0.94	0.8	0.67
RR093373	1	2	15.5	2.18	4.86	0.29	0.32

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RR093373	1	3	15.5	2.18	30.25	0.33	0.25
RR093373	2	1	16	38.24	0.89	1.91	0.85
RR093373	2	2	16	38.24	4.88	0.91	0.44
RR093373	2	3	16	38.24	33.08	0.95	0.33
RR093374	1	1	19.6	2.19	0.94	0.75	0.53
RR093374	1	2	19.6	2.19	4.86	0.22	0.29
RR093374	1	3	19.6	2.19	30.25	0.25	0.19
RR093374	2	1	20.8	38.25	0.89	1.14	0.58
RR093374	2	2	20.8	38.25	4.88	0.8	0.33
RR093374	2	3	20.8	38.25	33.08	1.02	0.28
RR093375	1	1	17.1	2.14	0.94	5	1.08
RR093375	1	2	17.1	2.14	5.07	5.33	0.76
RR093375	1	3	17.1	2.14	30.25	4.67	0.59
RR093375	2	1	19.9	38.19	0.89	4.77	0.95
RR093375	2	2	19.9	38.19	4.88	4.95	0.67
RR093375	2	3	19.9	38.19	33.08	4.95	0.55
RR093376	1	1	20.7	2.17	1.15	1.22	0.61
RR093376	1	2	20.7	2.17	5.07	0.82	0.32
RR093376	1	3	20.7	2.17	31.04	0.33	0.22
RR093376	2	1	19.8	38.23	0.89	0.57	0.59
RR093376	2	2	19.8	38.23	4.88	0.15	0.3
RR093376	2	3	19.8	38.23	33.08	0.42	0.25
RR093377	1	1	18.3	2.1	1.15	22.17	1.94
RR093377	1	2	18.3	2.1	5.07	16.63	1.26
RR093377	1	3	18.3	2.1	31.04	13.69	0.97
RR093377	2	1	17	38.16	0.89	11.93	1.53
RR093377	2	2	17	38.16	4.88	11.84	1.1
RR093377	2	3	17	38.16	33.08	12.02	0.93
RR093378	1	1	20	2.17	1.15	15.84	1.58
RR093378	1	2	20	2.17	5.07	6.66	0.78
RR093378	1	3	20	2.17	31.04	4.74	0.54
RR093378	2	1	16.5	38.23	0.89	4.57	1.08
RR093378	2	2	16.5	38.23	4.88	3.46	0.65
RR093378	2	3	16.5	38.23	33.08	4.05	0.56
RR093660	1	1	24	3.22	0.89	3.54	0.74
RR093660	1	2	24	3.22	4.88	2.35	0.43
RR093660	1	3	24	3.22	33.08	1.88	0.32
RR093660	2	1	17.2	268.23	0.11	4.48	1.3
RR093660	2	2	17.2	268.23	5.98	2.52	0.54
RR093660	2	3	17.2	268.23	42.75	1.36	0.36
RR093661	1	1	26.9	3.33	0.89	1.61	0.6
RR093661	1	2	26.9	3.33	4.88	0.86	0.28
RR093661	1	3	26.9	3.33	33.08	0.43	0.18
RR093661	2	1	22.9	268.34	0.11	1.34	0.71

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RR093661	2	2	22.9	268.34	5.98	0.59	0.27
RR093661	2	3	22.9	268.34	42.75	0.54	0.21
RR093662	1	1	23.2	3.03	0.89	14.11	1.65
RR093662	1	2	23.2	3.03	4.88	9.55	0.89
RR093662	1	3	23.2	3.03	33.08	8.94	0.72
RR093662	2	1	25.9	268.05	0.11	11.12	1.46
RR093662	2	2	25.9	268.05	5.98	10.26	0.83
RR093662	2	3	25.9	268.05	42.75	10.7	0.75
RR093663	1	1	24.1	3.09	0.89	13.99	1.59
RR093663	1	2	24.1	3.09	4.88	4.46	0.59
RR093663	1	3	24.1	3.09	33.08	3.46	0.43
RR093663	2	1	22.7	268.1	0.11	12.6	1.68
RR093663	2	2	22.7	268.1	5.98	5.26	0.64
RR093663	2	3	22.7	268.1	42.75	4.69	0.52
RR093664	1	1	17.7	3.2	0.89	6.88	1.31
RR093664	1	2	17.7	3.2	4.88	4.55	0.68
RR093664	1	3	17.7	3.2	33.08	4.09	0.54
RR093664	2	1	24.1	268.21	0.33	6.14	1.14
RR093664	2	2	24.1	268.21	5.98	4.92	0.59
RR093664	2	3	24.1	268.21	42.75	4.39	0.48
RS095390	1	1	26.8	2.18	0.33	11.41	1.39
RS095390	1	2	26.8	2.18	5.98	4.96	0.58
RS095390	1	3	26.8	2.18	42.75	3.86	0.44
RS095390	2	1	14.2	84.07	4.16	4.77	0.65
RS095390	2	2	14.2	84.07	7.38	4.29	0.85
RS095390	2	3	14.2	84.07	34.13	6.23	1.6
RS095391	1	1	25.3	2.18	0.33	18.71	1.8
RS095391	1	2	25.3	2.18	5.98	8.95	0.78
RS095391	1	3	25.3	2.18	42.75	7.47	0.62
RS095391	2	1	14.3	84.08	4.16	7.43	0.78
RS095391	2	2	14.3	84.08	7.38	7.74	1.05
RS095391	2	3	14.3	84.08	34.13	6.48	1.53
RS095392	1	1	27.1	2.21	0.33	16.79	1.69
RS095392	1	2	27.1	2.21	5.98	7.83	0.72
RS095392	1	3	27.1	2.21	42.76	6.07	0.56
RS095392	2	1	12.6	84.1	4.16	5.84	0.74
RS095392	2	2	12.6	84.1	7.38	5.98	0.99
RS095392	2	3	12.6	84.1	34.13	5.48	1.52
RS095393	1	1	15.7	2.22	0.11	4.53	1.27
RS095393	1	2	15.7	2.22	5.98	1.67	0.5
RS095393	1	3	15.7	2.22	42.76	1.59	0.38
RS095393	2	1	11.7	84.11	4.16	1.49	0.47
RS095393	2	2	11.7	84.11	7.38	1.68	0.71
RS095393	2	3	11.7	84.11	34.13	1.87	1.36

Table N.1 (Continued)
Gross radium activity data for samples

Sample no.	Prep. No.	Count No.	Mass (mg)	T_1 (d)	T_2 (d)	GRA (pCi/L)	GRA error (pCi/L)
RS095394	1	1	26.1	1.21	0.11	2.99	0.88
RS095394	1	2	26.1	1.21	5.98	1.25	0.32
RS095394	1	3	26.1	1.21	42.76	0.67	0.21
RS095394	2	1	11.1	83.11	4.16	0.57	0.34
RS095394	2	2	11.1	83.11	7.38	1.55	0.64
RS095394	2	3	11.1	83.11	34.13	3.91	1.45
RS095395	1	1	24.6	2.63	0.11	8.11	1.26
RS095395	1	2	24.6	2.63	5.98	7.32	0.72
RS095395	1	3	24.6	2.63	42.76	7.51	0.63
RS095395	2	1	23.5	84.52	4.16	7.31	0.63
RS095395	2	2	23.5	84.52	7.38	7.36	0.83
RS095395	2	3	23.5	84.52	34.13	7.15	1.27
RS095396	1	1	16.1	1.14	0.11	3.11	1.08
RS095396	1	2	16.1	1.14	5.98	0.35	0.33
RS095396	1	3	16.1	1.14	43	0.5	0.28
RS095396	2	1	10.7	83.03	4.16	0.68	0.34
RS095396	2	2	10.7	83.03	7.38	0.56	0.48
RS095396	2	3	10.7	83.03	34.13	1.23	1.03
RS095397	1	1	15.3	3.14	1.15	1.05	0.64
RS095397	1	2	15.3	3.14	5.3	0.72	0.37
RS095397	1	3	15.3	3.14	42.09	0.27	0.26
RS095397	2	1	12.1	84.13	4.16	0.44	0.29
RS095397	2	2	12.1	84.13	7.38	0.74	0.48
RS095397	2	3	12.1	84.13	34.13	2.1	1.13
RS095398	1	1	22.4	2.93	1.15	5.02	0.9
RS095398	1	2	22.4	2.93	5.3	2.17	0.45
RS095398	1	3	22.4	2.93	42.09	2.07	0.35
RS095398	2	1	13.9	83.92	4.16	1.83	0.46
RS095398	2	2	13.9	83.92	7.38	1.79	0.64
RS095398	2	3	13.9	83.92	34.13	4.06	1.43
RS095399	1	1	17.4	4.24	1.25	2.93	0.55
RS095399	1	2	17.4	4.24	3.45	4.65	0.64
RS095399	1	3	17.4	4.24	38.04	5.04	0.6
RS095399	2	1	12.1	81.18	4.16	4.21	0.66
RS095399	2	2	12.1	81.18	7.38	4.66	0.92
RS095399	2	3	12.1	81.18	34.13	6.45	1.7
RS095400	1	1	19.3	4.27	1.25	7.12	0.79
RS095400	1	2	19.3	4.27	3.45	6.26	0.7
RS095400	1	3	19.3	4.27	38.04	6.44	0.65
RS095400	2	1	11.7	81.21	4.16	6.38	0.79
RS095400	2	2	11.7	81.21	7.38	6.36	1.05
RS095400	2	3	11.7	81.21	34.13	8	1.84

APPENDIX O
RADIOCHEMICAL DATA

URANIUM DATA

Table O.1
^{234}U, ^{235}U, and ^{238}U activities of the samples

Sample no.	^{238}U activity (pCi/L)	Error (pCi/L)	^{235}U activity (pCi/L)	Error (pCi/L)	^{234}U activity (pCi/L)	Error (pCi/L)
RQ091434	0.21	0.03	0.03	0.01	3.25	0.15
RQ091435	0.23	0.03	0.01	0.01	1.92	0.11
RQ091436	0.19	0.03	0.01	0.01	2.84	0.13
RQ091437	0.10	0.02	0.01	0.01	1.69	0.10
RQ091438	0.08	0.02	0.01	0.01	0.66	0.07
RQ091439	1342.30	56.13	55.33	5.84	1556.03	64.03
RQ091440	1784.85	29.45	78.23	5.16	3003.96	42.09
RQ091441	0.61	0.06	0.03	0.01	0.78	0.07
RQ091442	0.11	0.02	0.01	0.01	1.65	0.10
RQ091444	1.14	0.06	0.07	0.01	7.08	0.16
RQ091713	0.03	0.01	0.01	0.01	0.06	0.02
RQ091720	0.04	0.01	0.02	0.01	0.03	0.01
RQ091721	16.16	0.55	0.74	0.07	49.88	1.48
RQ091722	0.21	0.04	0.02	0.01	0.19	0.04
RQ091723	0.09	0.03	0.01	0.01	0.13	0.04
RQ091724	0.07	0.02	0.01	0.01	0.12	0.03
RQ091725	0.01	0.01	0.00	0.00	0.12	0.02
RQ091726	0.07	0.02	0.04	0.01	0.35	0.04
RQ091751	0.27	0.02	0.01	0.01	1.53	0.06
RQ091992	0.00	0.01	0.00	0.00	0.01	0.01
RQ091993	13.21	0.32	0.57	0.05	19.21	0.43
RQ091994	8.14	0.22	0.34	0.04	12.32	0.29
RQ091995	0.12	0.02	0.01	0.01	0.14	0.02
RQ091996	0.15	0.03	0.01	0.01	0.58	0.05
RQ091997	0.03	0.01	0.00	0.00	0.11	0.02
RQ091998	0.14	0.03	0.02	0.01	1.85	0.11
RQ091999	0.32	0.04	0.02	0.01	3.19	0.14
RQ092000	0.07	0.01	0.01	0.01	0.90	0.05
RQ092001	0.09	0.02	0.01	0.01	1.54	0.06
RQ092029	0.01	0.01	0.00	0.01	0.02	0.01
RQ092250	10.24	0.18	0.43	0.03	11.32	0.19
RQ092251	0.25	0.04	0.01	0.01	1.85	0.10
RQ092252	0.12	0.02	0.00	0.01	0.54	0.04

Table O.1 (Continued)
^{238}U, ^{235}U, and ^{234}U activities of the samples

Sample no.	^{238}U activity (pCi/L)	Error (pCi/L)	^{235}U activity (pCi/L)	Error (pCi/L)	^{234}U activity (pCi/L)	Error (pCi/L)
RQ092253	8.84	0.16	0.34	0.03	8.66	0.16
RQ092254	7.62	0.14	0.32	0.03	7.98	0.15
RQ092255	0.04	0.01	0.01	0.00	0.25	0.03
RQ092256	21.86	0.36	0.87	0.06	34.26	0.48
RQ092257	95.72	1.51	4.05	0.26	139.94	1.96
RQ092258	0.05	0.02	0.00	0.01	0.07	0.02
RQ092847	8.97	0.24	0.37	0.04	10.99	0.28
RQ092848	22.67	0.39	1.01	0.07	27.88	0.45
RQ092849	3.67	0.16	0.15	0.03	15.48	0.47
RQ092850	3.89	0.17	0.16	0.03	4.58	0.19
RQ092851	3.14	0.14	0.13	0.02	4.25	0.17
RQ092852	115.00	1.97	5.01	0.33	149.38	2.37
RQ092853	117.91	2.00	5.37	0.34	169.72	2.59
RQ092854	0.07	0.01	0.00	0.00	0.09	0.02
RQ092855	13.61	0.22	0.59	0.04	22.50	0.31
RQ092856	12.05	0.31	0.53	0.05	15.82	0.38
RR093078	14.94	0.25	0.61	0.04	20.39	0.31
RR093079	0.07	0.03	0.00	0.02	0.17	0.06
RR093080	0.09	0.02	0.01	0.01	1.79	0.10
RR093081	0.22	0.04	0.03	0.02	3.42	0.18
RR093082	0.08	0.02	0.01	0.01	0.29	0.03
RR093083	0.03	0.01	0.01	0.01	0.35	0.04
RR093084	0.08	0.02	0.01	0.01	0.35	0.04
RR093085	0.08	0.02	0.00	0.01	0.76	0.05
RR093373	12.97	0.23	0.55	0.04	14.93	0.25
RR093374	10.22	0.18	0.49	0.04	15.68	0.24
RR093375	2.02	0.07	0.10	0.02	3.15	0.09
RR093376	13.00	0.21	0.58	0.04	19.23	0.27
RR093377	0.01	0.01	0.00	0.00	0.05	0.01
RR093378	0.02	0.01	0.00	0.01	0.03	0.02
RR093660	11.05	0.34	0.72	0.08	36.77	0.80
RR093661	0.07	0.02	0.03	0.02	0.11	0.04
RR093662	0.50	0.04	0.04	0.01	1.24	0.06
RR093663	0.05	0.02	0.03	0.01	0.23	0.04
RR093664	1.66	0.08	0.08	0.02	2.91	0.11
RS095390	0.08	0.03	0.01	0.01	1.05	0.10
RS095391	0.20	0.02	0.01	0.00	3.11	0.08
RS095392	0.15	0.02	0.01	0.01	2.76	0.08
RS095393	0.02	0.01	0.00	0.00	0.04	0.01

Table O.1 (Continued)
^{238}U, ^{235}U, and ^{234}U activities of the samples

Sample no.	^{238}U activity (pCi/L)	Error (pCi/L)	^{235}U activity (pCi/L)	Error (pCi/L)	^{234}U activity (pCi/L)	Error (pCi/L)
RS095394	0.22	0.02	0.01	0.01	0.29	0.03
RS095395	6.67	0.13	0.29	0.03	6.06	0.13
RS095396	28.18	0.46	1.17	0.08	36.94	0.56
RS095397	5.55	0.12	0.26	0.02	9.12	0.16
RS095398	0.92	0.05	0.06	0.01	3.15	0.09
RS095399	11.81	0.26	0.45	0.05	18.12	0.33
RS095400	27.08	0.46	1.12	0.08	35.07	0.56

RADIUM DATA

Table O.2
^{224}Ra, ^{226}Ra, and ^{228}Ra activities of the samples

Sample no.	^{224}Ra activity (pCi/L)	^{224}Ra error (pCi/L)	^{226}Ra activity (pCi/L)	^{226}Ra error (pCi/L)	^{228}Ra activity (pCi/L)	^{228}Ra error (pCi/L)
RQ091434	17.13	2.10	14.53	0.45	12.61	0.86
RQ091435	7.28	1.33	5.73	0.28	4.16	0.55
RQ091436	6.11	1.01	6.36	0.29	4.19	0.54
RQ091437	6.07	0.92	4.73	0.27	3.98	0.55
RQ091438	12.60	2.00	3.87	0.22	9.61	0.77
RQ091439	2.62	1.87	1.84	0.16	0.4	0.34
RQ091440	0.19	0.17	0.09	0.08	0.48	0.36
RQ091441	5.27	0.99	4.02	0.23	3.24	0.54
RQ091442	9.17	2.42	5.92	0.27	5.24	0.69
RQ091444	1.66	1.35	1.79	0.17	0.68	0.36
RQ091713	5.47	0.97	3.44	0.23	3.27	0.64
RQ091720	9.83	1.19	4.62	0.25	6.2	0.61
RQ091721	1.30	0.34	3.61	0.25	1.54	0.4
RQ091722	10.88	1.23	26.89	0.59	16.09	0.89
RQ091723	7.47	1.76	1.41	0.17	4.99	0.55
RQ091724	5.92	1.34	1.3	0.16	6.03	0.63
RQ091725	2.99	0.48	4.03	0.24	2.57	0.44
RQ091726	2.26	0.39	3.94	0.23	2.62	0.45
RQ091751	12.21	1.96	4.5	0.25	12.38	0.81
RQ091992	-0.01	0.08	0.14	0.05	-0.07	0.35
RQ091993	1.04	0.75	0.31	0.07	0.67	0.43
RQ091994	0.97	0.72	0.27	0.07	0.47	0.35
RQ091995	6.79	1.28	1.77	0.15	6	0.65
RQ091996	4.99	0.68	6.25	0.28	6.07	0.66

Table O.2 (Continued)
^{224}Ra, ^{226}Ra, and ^{228}Ra activities of the samples

Sample no.	^{224}Ra activity (pCi/L)	^{224}Ra error (pCi/L)	^{226}Ra activity (pCi/L)	^{226}Ra error (pCi/L)	^{228}Ra activity (pCi/L)	^{228}Ra error (pCi/L)
RQ091997	0.85	0.25	7.2	0.28	0.22	0.33
RQ091998	2.51	0.85	3.91	0.22	2.32	0.45
RQ091999	6.88	1.57	6.42	0.29	4.23	0.58
RQ092000	7.86	1.36	4.23	0.24	6.39	0.67
RQ092001	9.18	1.44	7.93	0.31	8.12	0.76
RQ092029	0.08	0.14	0.08	0.07	0.01	0.31
RQ092250	1.07	0.86	0.2	0.06	0.4	0.32
RQ092251	1.30	0.29	2.81	0.19	0.18	0.32
RQ092252	1.75	0.43	7.74	0.31	0.6	0.32
RQ092253	1.56	1.17	0.12	0.05	0.29	0.29
RQ092254	4.83	3.83	0.14	0.07	0.21	0.29
RQ092255	7.04	1.01	2.95	0.2	2.01	0.44
RQ092256	3.72	3.00	0.74	0.11	0.72	0.36
RQ092257	4.72	3.47	1.51	0.15	2.22	0.45
RQ092258	4.31	0.57	4.42	0.23	0.22	0.27
RQ092847	0.12	0.12	0.08	0.05	0.18	0.28
RQ092848	0.23	0.19	0.11	0.06	0.63	0.34
RQ092849	2.57	0.58	2.23	0.18	1.62	0.41
RQ092850	0.19	0.16	0.11	0.07	0.48	0.33
RQ092851	0.18	0.16	0.07	0.07	0.01	0.26
RQ092852	0.40	0.31	0.35	0.07	0.21	0.31
RQ092853	6.15	0.82	10.65	0.36	2.56	0.45
RQ092854	4.91	3.72	0.57	0.09	1.86	0.41
RQ092855	0.65	0.50	0.48	0.11	0.34	0.37
RQ092856	0.43	0.35	0.23	0.07	-0.09	0.3
RR093078	0.48	0.39	0.33	0.09	0.75	0.32
RR093079	2.34	1.10	6.29	0.29	1.5	0.37
RR093080	3.16	0.89	0.99	0.13	2.14	0.47
RR093081	32.85	3.45	7.51	0.32	27.45	1.22
RR093082	8.01	1.52	4.39	0.24	7.08	0.68
RR093083	9.21	1.73	5.26	0.27	6.35	0.65
RR093084	10.17	2.36	4.61	0.25	7.77	0.7
RR093085	3.48	0.90	2.71	0.2	2.28	0.53
RR093373	0.19	0.16	0.14	0.08	0.19	0.3
RR093374	0.30	0.22	0.15	0.06	0.19	0.32
RR093375	0.86	0.22	4.11	0.25	0.4	0.34
RR093376	0.44	0.32	0.09	0.07	0.1	0.3
RR093377	9.06	1.40	13.97	0.45	0.66	0.36
RR093378	7.72	1.54	3.76	0.24	7.95	0.73

Table O.2 (Continued)
^{224}Ra, ^{226}Ra, and ^{228}Ra activities of the samples

Sample no.	^{224}Ra activity (pCi/L)	^{224}Ra error (pCi/L)	^{226}Ra activity (pCi/L)	^{226}Ra error (pCi/L)	^{228}Ra activity (pCi/L)	^{228}Ra error (pCi/L)
RR093660	1.14	0.45	1.19	0.24	1.17	0.55
RR093661	0.13	0.18	0.34	0.12	0.14	0.54
RR093662	2.39	0.49	9.52	0.37	2.96	0.49
RR093663	6.73	1.20	3.54	0.24	7.17	0.7
RR093664	0.97	0.37	4.62	0.27	0.27	0.33
RS095390	4.11	0.63	4.05	0.25	5.02	0.71
RS095391	4.53	0.74	6.92	0.32	4.11	0.61
RS095392	4.59	0.75	5.72	0.3	2.74	0.55
RS095393	0.61	0.40	1.09	0.12	1.62	0.55
RS095394	0.18	0.17	0.11	0.05	1	0.44
RS095395	0.67	0.28	7.07	0.28	0.59	0.39
RS095396	0.04	0.08	0.28	0.08	1.11	0.45
RS095397	0.13	0.19	0.09	0.07	0.17	0.31
RS095398	3.61	0.86	2.97	0.2	1.05	0.42
RS095399	2.80	0.72	4.58	0.25	1.79	0.43
RS095400	7.78	1.27	6.46	0.29	3.85	0.53

THORIUM DATA

Table O.3
^{228}Th, ^{230}Th, and ^{232}Th activities of the samples

Sample no.	^{228}Th activity (pCi/L)	^{228}Th error (pCi/L)	^{230}Th activity (pCi/L)	^{230}Th error (pCi/L)	^{232}Th activity (pCi/L)	^{232}Th error (pCi/L)
RQ091434	0.00	0.04	0.02	0.14	0.04	0.02
RQ091435	0.03	0.03	0.06	0.16	0.03	0.02
RQ091436	0.03	0.03	0.10	0.14	0.02	0.01
RQ091437	0.04	0.03	0.04	0.30	0.01	0.01
RQ091438	0.17	0.05	0.08	0.16	0.03	0.02
RQ091439	0.02	0.03	0.02	0.14	0.02	0.01
RQ091440	0.05	0.03	0.01	0.30	0.02	0.01
RQ091441	0.07	0.03	0.12	0.16	0.02	0.01
RQ091442	0.01	0.03	-0.03	0.14	0.01	0.01
RQ091444	0.04	0.02	0.03	0.29	0.02	0.01
RQ091713	-0.08	0.11	-0.19	0.09	0.01	0.01
RQ091720	0.03	0.11	-0.02	0.10	0.01	0.01
RQ091721	0.06	0.07	-0.19	0.09	0.00	0.01
RQ091722	-0.16	0.18	-0.19	0.10	0.02	0.01

Table O.3 (Continued)
^{228}Th, ^{230}Th, and ^{232}Th activities of the samples

Sample no.	^{228}Th activity (pCi/L)	^{228}Th error (pCi/L)	^{230}Th activity (pCi/L)	^{230}Th error (pCi/L)	^{232}Th activity (pCi/L)	^{232}Th error (pCi/L)
RQ091723	-0.13	0.10	-0.20	0.10	0.01	0.01
RQ091724	-0.04	0.12	-0.06	0.10	0.03	0.01
RQ091725	0.01	0.08	-0.12	0.09	0.01	0.01
RQ091726	-0.01	0.08	-0.24	0.09	0.01	0.01
RQ091751	-0.14	0.16	-0.33	0.10	0.01	0.01
RQ091992	0.07	0.07	0.26	0.23	0.03	0.03
RQ091993	0.13	0.08	0.56	0.17	0.03	0.02
RQ091994	0.22	0.09	0.55	0.30	0.02	0.01
RQ091995	-0.08	0.13	-0.04	0.11	0.02	0.01
RQ091996	0.29	0.19	0.85	0.27	0.02	0.02
RQ091997	0.08	0.06	0.26	0.16	0.02	0.01
RQ091998	0.09	0.09	0.46	0.29	0.03	0.01
RQ091999	0.05	0.12	0.20	0.11	0.01	0.01
RQ092000	-0.07	0.13	-0.07	0.09	0.01	0.01
RQ092001	0.15	0.17	0.71	0.18	0.03	0.02
RQ092029	0.08	0.06	0.84	0.31	0.03	0.01
RQ092250	0.04	0.05	0.18	0.11	0.01	0.01
RQ092251	0.03	0.04	0.19	0.16	0.04	0.02
RQ092252	0.08	0.05	0.01	0.29	0.02	0.01
RQ092253	0.00	0.04	-0.20	0.10	0.01	0.01
RQ092254	0.03	0.04	-0.16	0.09	0.01	0.01
RQ092255	0.06	0.08	1.40	0.36	0.05	0.03
RQ092256	1.91	0.26	0.68	0.59	0.06	0.03
RQ092257	1.18	0.13	0.55	0.12	0.02	0.01
RQ092258	0.03	0.05	0.08	0.21	0.04	0.03
RQ092847	0.00	0.04	0.23	0.16	0.06	0.02
RQ092848	-0.02	0.04	-0.09	0.10	0.02	0.01
RQ092849	0.08	0.07	-0.39	0.19	0.03	0.02
RQ092850	-0.01	0.04	0.02	0.10	0.04	0.01
RQ092851	0.02	0.03	-0.26	0.10	0.01	0.01
RQ092852	0.04	0.04	0.18	0.16	0.03	0.01
RQ092853	0.53	0.15	0.49	0.33	0.07	0.03
RQ092854	0.00	0.05	-0.12	0.09	0.02	0.01
RQ092855	0.01	0.05	-0.15	0.09	0.01	0.01
RQ092856	0.02	0.04	-0.33	0.09	0.01	0.01
RR093078	0.00	0.03	0.10	0.16	0.07	0.01
RR093079	-0.02	0.08	0.04	0.43	0.05	0.03
RR093080	0.04	0.11	0.37	0.41	0.05	0.03
RR093081	0.02	0.15	-0.43	0.19	0.03	0.01

Table O.3 (Continued)
^{228}Th, ^{230}Th, and ^{232}Th activities of the samples

Sample no.	^{228}Th activity (pCi/L)	^{228}Th error (pCi/L)	^{230}Th activity (pCi/L)	^{230}Th error (pCi/L)	^{232}Th activity (pCi/L)	^{232}Th error (pCi/L)
RR093082	-0.02	0.12	-0.28	0.20	0.03	0.02
RR093083	0.02	0.12	-0.44	0.20	0.03	0.02
RR093084	-0.08	0.06	0.00	0.09	0.01	0.01
RR093085	-0.01	0.04	0.18	0.10	0.03	0.01
RR093373	0.01	0.02	-0.08	0.10	0.01	0.01
RR093374	0.02	0.02	0.08	0.10	0.01	0.01
RR093375	0.03	0.10	0.01	0.10	0.03	0.01
RR093376	0.02	0.02	0.38	0.11	0.02	0.01
RR093377	0.01	0.02	0.12	0.09	0.01	0.01
RR093378	-0.01	0.05	-0.06	0.09	0.01	0.01
RR093660	0.04	0.13	0.84	0.34	0.23	0.04
RR093661	0.00	0.12	-0.50	0.20	0.02	0.01
RR093662	-0.07	0.12	0.55	0.20	0.09	0.02
RR093663	0.02	0.19	0.24	0.20	0.08	0.02
RR093664	0.01	0.08	0.14	0.32	0.03	0.01
RS095390	0.01	0.04	0.09	0.10	0.02	0.01
RS095391	0.09	0.04	1.00	0.19	0.29	0.04
RS095392	0.04	0.03	0.06	0.10	0.01	0.01
RS095393	-0.01	0.03	-0.07	0.09	0.01	0.01
RS095394	0.53	0.05	0.45	0.11	0.13	0.02
RS095395	0.03	0.02	0.41	0.17	0.02	0.01
RS095396	0.00	0.02	-0.02	0.10	0.01	0.01
RS095397	0.07	0.02	1.10	0.13	0.11	0.02
RS095398	0.14	0.03	0.07	0.10	0.10	0.02
RS095399	0.06	0.04	0.52	0.33	0.06	0.02
RS095400	0.01	0.03	0.09	0.10	0.02	0.01

^{210}PB AND ^{210}PO DATA

Table O.4
^{210}Pb and ^{210}Po activities of the samples

Sample no.	^{210}Pb activity (pCi/L)	^{210}Pb error (pCi/L)	^{210}Po activity (pCi/L)	^{210}Poerror (pCi/L)
RQ091434	0.23	0.47	0.03	0.09
RQ091435	-0.09	0.47	0.10	0.07
RQ091436	0.1	0.56	-0.01	0.11
RQ091437	0.41	0.53	0.11	0.08
RQ091438	0.23	0.48	0.03	0.07

Table O.4 (Continued)
^{210}Pb and ^{210}Po activities of the samples

Sample no.	^{210}Pb activity (pCi/L)	^{210}Pb error (pCi/L)	^{210}Po activity (pCi/L)	^{210}Poerror (pCi/L)
RQ091439	2.4	0.69	2.41	0.26
RQ091440	0.83	0.64	0.12	0.13
RQ091441	0.26	0.39	-0.02	0.08
RQ091442	0.07	0.36	0.12	0.06
RQ091444	-0.18	0.43	0.14	0.09
RQ091713	-0.05	0.36	0.07	0.05
RQ091720	0.01	0.38	0.10	0.05
RQ091721	2.66	0.48	2.91	0.25
RQ091722	0.51	0.42	0.02	0.06
RQ091723	-0.18	0.39	0.03	0.05
RQ091724	-0.07	0.34	0.11	0.05
RQ091725	-0.05	0.34	0.03	0.05
RQ091726	0.43	0.35	-0.04	0.05
RQ091751	-0.02	0.34	0.29	0.06
RQ091992	0.35	0.39	1.91	0.24
RQ091993	0.21	0.39	-0.07	0.18
RQ091994	-0.21	0.35	0.17	0.18
RQ091995	0.11	0.4	-0.01	0.20
RQ091996	1.62	0.55	0.46	0.29
RQ091997	2.55	0.6	3.17	0.41
RQ091998	-0.02	0.32	0.11	0.16
RQ091999	0.13	0.34	0.01	0.18
RQ092000	0.42	0.4	-0.20	0.20
RQ092001	-0.16	0.38	0.12	0.20
RQ092029	0.4	0.42	4.11	0.39
RQ092250	-0.09	0.31	0.13	0.25
RQ092251	0.15	0.33	-0.04	0.26
RQ092252	0.29	0.37	-0.20	0.30
RQ092253	0	0.33	0.10	0.27
RQ092254	0.07	0.35	0.05	0.29
RQ092255	0.14	0.35	-0.05	0.28
RQ092256	4.6	0.72	27.40	1.92
RQ092257	3.4	0.63	5.72	0.83
RQ092258	0.48	0.37	-0.18	0.35
RQ092847	3.7	0.69	0.89	0.98
RQ092848	0.49	0.47	0.70	0.62
RQ092849	0.72	0.45	8.03	0.90
RQ092850	0.53	0.45	2.66	0.70
RQ092851	-0.03	0.42	0.25	0.59

Table O.4 (Continued)
^{210}Pb and ^{210}Po activities of the samples

Sample no.	^{210}Pb activity (pCi/L)	^{210}Pb error (pCi/L)	^{210}Po activity (pCi/L)	^{210}Poerror (pCi/L)
RQ092852	0.53	0.44	1.86	0.65
RQ092853	14.39	1.45	4.39	2.50
RQ092854	0.35	0.41	0.53	0.59
RQ092855	0.05	0.36	0.01	0.51
RQ092856	-0.1	0.42	0.27	0.59
RR093078	0.29	0.96	-0.22	0.94
RR093079	0.34	0.65	0.35	0.56
RR093080	0.55	0.64	-0.44	0.63
RR093081	0.6	0.6	-0.53	0.59
RR093082	0.35	0.52	-0.27	0.51
RR093083	0.37	0.49	-0.34	0.52
RR093084	0.31	0.43	-0.30	0.46
RR093085	0.3	0.49	-0.27	0.52
RR093373	0.27	0.3	0.17	0.38
RR093374	-0.15	0.3	0.22	0.37
RR093375	0.24	0.33	0.22	0.41
RR093376	0.14	0.32	-0.03	0.40
RR093377	0.29	0.27	-0.03	0.34
RR093378	0.16	0.31	-0.18	0.39
RR093660	1.02	0.38	1.32	0.38
RR093661	-0.23	0.3	0.24	0.27
RR093662	0.54	0.4	0.07	0.37
RR093663	-0.01	0.34	0.08	0.31
RR093664	0.07	0.35	-0.02	0.32
RS095390	0.1	0.39	-0.05	0.39
RS095391	0.18	0.42	-0.06	0.42
RS095392	0.47	0.42	-0.28	0.37
RS095393	0.38	0.52	-0.17	0.52
RS095394	0.32	0.41	55.57	3.32
RS095395	0.87	0.44	-0.50	0.45
RS095396	4.17	0.63	3.14	0.69
RS095397	0.32	0.42	-0.03	0.37
RS095398	0.03	0.45	0.36	0.40
RS095399	0.06	0.4	0.34	0.36
RS095400	0.77	0.4	-0.09	0.40

APPENDIX P
INORGANIC DATA

METAL CONCENTRATIONS OF THE SAMPLES

Table P.1
Metal concentrations of the samples

Sample no.	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Ba (µg/L)	Mn (µg/L)	Fe (mg/L)
RQ091434	582.95	17.54	83.27	36.59	7.67	167.11	1.25
RQ091435	654.92	10.90	35.66	13.23	8.79	17.04	0.57
RQ091436	54.00	14.90	57.55	19.21	27.07	6.02	0.47
RQ091437	44.88	13.57	54.65	15.19	59.83	4.99	0.16
RQ091438	5.30	3.22	70.12	28.35	82.50	23.02	0.19
RQ091439	7.60	0.36	32.10	0.89	-0.12	0.88	0.00
RQ091440	13.36	2.44	27.97	1.34	0.51	0.67	0.00
RQ091441	118.49	5.96	31.60	11.79	36.96	49.18	0.35
RQ091442	12.88	3.90	71.68	24.73	46.02	51.55	0.32
RQ091444	11.01	3.18	90.57	27.14	162.08	168.48	0.28
RQ091713	17.20	1.68	2.89	2.67	76.96	16.17	0.20
RQ091720	40.84	2.70	5.93	5.52	186.59	34.73	0.22
RQ091721	13.93	1.28	46.13	13.34	22.24	77.29	0.33
RQ091722	4.87	0.98	3.07	4.21	107.74	6.79	0.00
RQ091723	1.56	0.66	1.40	1.29	31.53	10.06	0.00
RQ091724	3.26	0.30	0.90	1.28	31.92	7.02	0.22
RQ091725	9.07	2.15	96.40	29.70	302.36	19.58	0.43
RQ091726	7.53	1.77	84.14	27.12	259.87	20.33	0.39
RQ091751	41.30	3.09	123.76	50.16	41.00	141.00	1.13
RQ091992	121.32	4.24	1.15	0.32	20.80	28.48	0.47
RQ091993	59.74	6.12	90.61	16.67	98.35	27.49	0.04
RQ091994	61.01	6.25	78.00	15.12	87.87	31.00	0.06
RQ091995	2.91	0.38	0.62	0.48	16.72	19.92	0.00
RQ091996	8.29	3.17	17.34	3.00	19.27	77.68	1.13
RQ091997	8.29	2.60	19.83	2.73	8.49	90.20	0.52
RQ091998	36.57	4.35	86.00	42.22	40.07	10.35	0.05
RQ091999	38.12	3.97	99.84	32.55	57.15	45.30	0.14
RQ092000	37.20	15.85	58.99	19.93	68.18	4.10	0.20
RQ092001	55.20	15.03	58.09	18.97	41.21	5.25	0.19
RQ092029	122.00	0.62	0.74	0.07	1.07	3.42	0.00
RQ092250	115.71	5.69	143.87	33.45	71.06	71.52	0.00
RQ092251	32.72	4.49	63.64	31.80	86.00	2.24	0.02
RQ092252	191.29	6.21	73.34	26.04	172.51	5.83	0.18
RQ092253	52.16	1.78	152.30	44.21	88.33	-0.19	0.00

Table P.1 (Continued)
Metal concentrations of the samples

Sample no.	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Ba (µg/L)	Mn (µg/L)	Fe (mg/L)
RQ092254	59.57	7.90	78.37	16.51	41.90	10.20	0.12
RQ092255	6.53	3.09	40.54	16.71	145.56	35.46	0.07
RQ092256	49.39	1.84	6.23	1.51	8.99	85.35	1.29
RQ092257	94.98	1.78	23.38	3.73	1.89	449.98	0.34
RQ092258	11.30	2.40	28.60	3.40	196.00	50.00	ND
RQ092847	11.77	0.84	8.96	1.34	0.61	2.23	0.18
RQ092848	7.29	1.09	19.83	2.37	1.47	0.66	0.37
RQ092849	10.93	0.46	31.31	0.81	23.60	166.20	0.07
RQ092850	17.63	0.35	4.42	0.18	2.03	3.18	0.01
RQ092851	22.29	1.47	8.73	0.42	2.02	0.03	0.00
RQ092852	17.16	0.88	17.28	0.70	3.17	0.34	0.00
RQ092853	7.01	3.47	22.45	4.18	11.33	142.16	3.11
RQ092854	15.37	3.33	24.92	10.01	45.89	145.20	0.03
RQ092855	96.34	4.76	66.05	16.95	50.32	1.89	0.03
RQ092856	60.15	4.30	84.61	20.87	93.08	4.29	0.11
RR093078	28.07	6.46	46.63	12.70	58.36	0.09	0.01
RR093079	9.40	1.28	88.30	26.09	357.25	25.10	1.92
RR093080	8.28	1.53	47.65	26.43	86.73	-0.19	0.01
RR093081	6.54	1.45	52.44	28.94	103.77	1.38	0.20
RR093082	74.39	12.56	178.07	43.34	30.17	261.49	2.26
RR093083	85.51	15.48	163.24	37.15	20.27	220.75	2.00
RR093084	85.24	17.25	200.36	43.87	19.16	166.99	1.88
RR093085	15.16	7.16	77.55	23.72	30.32	148.28	0.79
RR093373	27.27	1.80	32.67	3.74	76.28	0.05	0.00
RR093374	99.78	10.73	91.91	15.80	93.52	9.97	0.04
RR093375	37.19	2.19	52.14	7.10	240.08	7.91	0.11
RR093376	110.55	11.10	108.60	17.76	66.66	50.67	0.01
RR093377	26.51	10.06	276.56	68.60	35.62	2.42	0.09
RR093378	516.57	12.51	53.57	10.15	15.80	92.77	0.76
RR093660	34.62	2.67	36.80	15.39	22.89	21.12	0.01
RR093661	25.87	1.77	104.40	14.08	17.98	0.11	0.00
RR093662	64.95	3.73	33.88	10.50	54.93	80.90	0.49
RR093663	50.45	8.08	78.42	25.06	33.23	29.79	0.93
RR093664	174.55	22.65	127.97	31.94	68.27	0.03	0.01
RS095390	25.00	8.90	66.90	26.00	118.00	1.00	0.30
RS095391	45.60	7.30	66.20	24.00	16.00	21.00	0.30
RS095392	31.00	6.20	54.40	20.80	23.00	18.00	0.30
RS095393	26.00	2.40	36.80	3.70	315.00	22.00	0.20
RS095394	129.00	2.40	ND	ND	10.00	25.00	0.40
RS095395	60.50	1.10	63.30	9.80	9.00	6.00	0.60

Table P.1 (Continued)
Metal concentrations of the samples

Sample no.	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Ba (µg/L)	Mn (µg/L)	Fe (mg/L)
RS095396	7.10	0.90	59.40	26.90	3.00	87.00	1.00
RS095397	35.80	2.40	230.00	51.50	15.00	ND	ND
RS095398	60.90	3.20	102.00	31.90	49.00	24.00	0.50
RS095399	98.40	3.00	66.60	36.40	45.00	55.00	ND
RS095400	71.00	2.50	102.00	28.50	54.00	219.00	0.60

CONCENTRATIONS OF SOME OF THE ANIONS OF THE SAMPLES

In the following table "SE" denotes a sampling error, "ND" denotes a value that was below the detection limit, and "NA" denotes a sample results that was not analyzed by mistake.

Table P.2
Concentrations of the anions of the samples

Sample no.	Chloride (mg/L)	Fluoride (mg/L)	Sulfide (mg/L)	Nitrate and Nitrite (mg/L)	Sulfate (mg/L)
RQ091434	18.88	1.94	ND	-0.28	1152.17
RQ091435	32.69	4.20	ND	-0.27	936.88
RQ091436	16.28	1.25	ND	-0.28	82.19
RQ091437	13.89	1.24	ND	-0.27	41.95
RQ091438	1.59	0.41	ND	-0.27	52.23
RQ091439	2.84	0.85	ND	0.79	25.07
RQ091440	4.64	1.58	ND	1.51	21.01
RQ091441	66.30	1.79	ND	-0.28	78.68
RQ091442	6.42	0.51	ND	-0.24	114.81
RQ091444	3.06	0.94	SE	SE	94.99
RQ091713	19.34	0.01	0.004	2.05	14.18
RQ091720	69.15	0.00	ND	4.78	5.23
RQ091721	40.95	0.73	ND	0.01	15.20
RQ091722	7.82	0.02	ND	7.59	0.13
RQ091723	2.18	0.03	ND	2.78	0.13
RQ091724	3.61	0.03	ND	2.40	0.13
RQ091725	23.43	0.24	ND	-0.17	35.55
RQ091726	13.64	0.33	ND	-0.17	31.22
RQ091751	1.06	0.33	ND	-0.14	141.48
RQ091992	1.07	1.40	ND	-0.16	12.20
RQ091993	27.75	0.42	ND	0.36	223.00
RQ091994	27.95	0.46	ND	0.34	193.00
RQ091995	3.61	0.03	ND	0.37	1.99
RQ091996	1.47	0.56	ND	-0.16	7.91

Table P.2 (Continued)
Concentrations of the anions of the samples

Sample no.	Chloride (mg/L)	Fluoride (mg/L)	Sulfide (mg/L)	Nitrate and Nitrite (mg/L)	Sulfate (mg/L)
RQ091997	1.21	0.30	ND	-0.17	7.27
RQ091998	59.40	0.43	ND	-0.13	183.00
RQ091999	98.60	0.44	ND	-0.14	124.00
RQ092000	13.16	1.04	SE	-0.16	30.60
RQ092001	22.74	1.27	ND	-0.17	72.80
RQ092029	5.55	0.78	0.030	-0.16	2.97
RQ092250	240.80	0.54	0.005	2.39	281.00
RQ092251	9.12	0.73	0.004	-0.05	21.70
RQ092252	257.25	0.70	0.003	-0.05	41.50
RQ092253	96.10	0.32	ND	5.87	258.00
RQ092254	18.81	0.68	0.003	0.20	184.50
RQ092255	2.08	0.28	ND	-0.02	26.30
RQ092256	16.23	0.61	ND	-0.02	14.00
RQ092257	67.95	0.78	0.009	-0.02	18.70
RQ092258	3.67	1.15	SE	SE	25.54
RQ092847	2.77	3.78	ND	-0.18	2.56
RQ092848	15.00	2.07	ND	0.01	1.61
RQ092849	0.25	3.40	ND	-0.23	4.70
RQ092850	2.02	0.25	ND	-0.21	5.24
RQ092851	12.68	0.27	ND	-0.01	7.68
RQ092852	1.66	1.29	ND	0.25	1.71
RQ092853	1.27	0.12	ND	-0.16	3.72
RQ092854	37.11	0.08	ND	0.31	24.70
RQ092855	33.59	0.27	ND	5.35	127.80
RQ092856	49.65	0.19	ND	3.69	154.00
RR093078	30.6	0.06	ND	3.92	17.9
RR093079	1.1	0.90	0.01	-0.18	ND
RR093080	4.1	0.26	ND	-0.08	31.6
RR093081	3.1	0.22	ND	-0.07	33.6
RR093082	22.2	0.99	ND	-0.08	390
RR093083	33.4	1.67	ND	-0.09	349
RR093084	36.9	1.64	ND	-0.09	530
RR093085	2.4	0.70	ND	-0.17	79.5
RR093373	13.50	0.54	ND	6.84	16.80
RR093374	33.60	0.56	0.01	5.02	173.00
RR093375	43.80	0.13	ND	-0.22	13.30
RR093376	37.00	0.36	0.01	3.79	160.00
RR093377	27.30	2.42	0.02	-0.18	808.00
RR093378	71.40	1.18	0.02	-0.17	990.00

Table P.2 (Continued)
Concentrations of the anions of the samples

Sample no.	Chloride (mg/L)	Fluoride (mg/L)	Sulfide (mg/L)	Nitrate and Nitrite (mg/L)	Sulfate (mg/L)
RR093660	26.70	1.72	ND	0.00	19.50
RR093661	SE	SE	SE	SE	SE
RR093662	7.78	2.40	0.003	-0.32	38.70
RR093663	10.80	0.66	0.004	-0.30	178.00
RR093664	258.00	1.17	ND	-0.19	307.00
RS095390	26.50	0.38	ND	ND	48.80
RS095391	60.30	2.75	ND	ND	140.00
RS095392	30.20	2.81	ND	ND	88.50
RS095393	21.70	0.12	0.01	ND	ND
RS095394	19.20	0.88	0.02	ND	76.20
RS095395	104.00	0.12	0.01	ND	ND
RS095396	38.20	0.48	0.01	0.59	34.70
RS095397	4.20	0.97	ND	2.07	522.00
RS095398	15.30	0.49	0.01	ND	267.00
RS095399	77.80	0.64	ND	ND	168.00
RS095400	55.10	0.53	0.04	ND	104.00

ALKALINITY, PH, CONDUCTIVITY, TURBIDITY, AND DISSOVLED SILICA (SIO_2)

In the following table "SE" denotes a sampling error.

Table P.3
Alkalinity, pH, conductivity, turbidity, and dissolved silica (SiO_2) of the samples

Sample no.	Alkalinity (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	pH (SU)	Silica (mg/L)
RQ091434	415.86	2841.00	7.70	7.44	9.85
RQ091435	529.12	2887.00	1.53	7.90	10.64
RQ091436	254.25	691.00	0.79	7.73	7.95
RQ091437	253.47	612.00	0.93	7.68	8.14
RQ091438	273.82	603.00	1.11	7.62	7.96
RQ091439	73.44	165.20	0.24	7.68	29.70
RQ091440	72.10	217.30	0.05	7.99	24.42
RQ091441	219.09	774.00	0.55	7.95	13.68
RQ091442	207.57	622.00	1.39	7.76	8.52
RQ091444	SE	SE	SE	SE	SE
RQ091713	6.78	138.10	0.155	5.76	10.87
RQ091720	0.89	318.60	0.191	4.67	12.47
RQ091721	112.78	394.90	0.446	7.30	27.23

Table P.3 (Continued)
Alkalinity, pH, conductivity, turbidity, and dissolved silica (SiO_2) of the samples

Sample no.	Alkalinity (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	pH (SU)	Silica (mg/L)
RQ091722	1.64	100.10	0.093	4.93	10.97
RQ091723	1.04	40.70	0.050	4.78	5.52
RQ091724	1.70	42.80	4.45	5.06	5.40
RQ091725	298.84	676.00	3.05	7.76	13.33
RQ091726	273.81	598.00	1.81	7.92	13.48
RQ091751	458.38	1020.00	12.4	7.65	14.71
RQ091992	262.17	526.00	0.75	7.76	37.76
RQ091993	168.64	831.00	0.37	7.53	21.15
RQ091994	159.76	769.00	0.65	7.62	21.29
RQ091995	2.08	34.87	0.25	4.96	5.26
RQ091996	62.59	153.10	8.16	7.37	38.08
RQ091997	68.14	160.90	1.27	7.22	40.84
RQ091998	206.00	908.00	0.67	7.66	20.49
RQ091999	218.89	988.00	1.28	7.64	8.53
RQ092000	268.63	608.00	0.67	7.82	8.67
RQ092001	255.04	693.00	2.01	7.69	8.56
RQ092029	245.69	496.00	0.20	9.03	18.52
RQ092250	273.69	1416.00	0.05	7.64	24.78
RQ092251	312.94	637.00	0.13	7.69	10.05
RQ092252	266.00	1393.00	0.54	7.71	11.20
RQ092253	238.60	1243.00	0.06	7.43	44.20
RQ092254	180.91	766.00	0.64	7.84	24.80
RQ092255	158.65	370.00	0.54	7.92	7.84
RQ092256	90.00	271.00	11.50	7.71	12.55
RQ092257	144.48	567.00	1.42	7.80	11.75
RQ092258	SE	SE	SE	SE	SE
RQ092847	39.40	118.20	0.48	7.81	16.75
RQ092848	50.11	174.50	0.19	7.92	18.00
RQ092849	92.86	217.50	0.63	7.47	24.60
RQ092850	42.54	111.80	0.18	8.76	20.90
RQ092851	49.09	170.70	0.06	8.64	23.70
RQ092852	83.76	184.90	0.05	8.98	30.50
RQ092853	83.93	185.70	7.72	7.58	27.60
RQ092854	70.90	324.10	0.20	6.60	29.80
RQ092855	277.95	915.00	0.10	7.50	47.40
RQ092856	220.11	905.00	0.60	7.42	48.80
RR093078	150.24	460.00	0.39	7.92	65.40
RR093079	324.96	607.00	23.00	7.49	22.80
RR093080	199.36	447.00	0.56	7.89	9.89
RR093081	217.72	477.00	0.40	7.92	9.52

Table P.3 (Continued)
Alkalinity, pH, conductivity, turbidity, and dissolved silica (SiO_2) of the samples

Sample no.	Alkalinity (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	pH (SU)	Silica (mg/L)
RR093082	342.56	1358.00	3.03	7.61	21.40
RR093083	306.52	1284.00	3.75	7.63	17.50
RR093084	273.75	1491.00	20.70	7.69	16.00
RR093085	240.96	610.00	12.00	7.64	7.64
RR093373	97.71	322.10	0.33	7.81	35.40
RR093374	267.24	952.00	0.12	7.69	49.80
RR093375	157.84	468.00	0.77	7.74	24.00
RR093376	364.31	1078.00	0.22	7.66	52.00
RR093377	113.11	1602.00	0.63	7.06	40.70
RR093378	186.33	2494.00	3.42	7.60	26.30
RR093660	172.07	457.00	3.28	7.99	13.45
RR093661	SE	SE	SE	SE	SE
RR093662	211.49	510.00	17.30	7.86	11.25
RR093663	206.69	760.00	1.13	7.55	13.40
RR093664	175.16	1673.00	0.04	7.59	40.60
RS095390	249.00	636.00	1.70	7.46	1.88
RS095391	149.00	753.00	1.40	7.76	7.11
RS095392	156.00	580.00	1.60	7.76	7.02
RS095393	127.00	327.00	0.80	7.83	23.50
RS095394	183.00	589.00	0.40	9.08	32.90
RS095395	185.00	695.00	0.20	7.35	6.32
RS095396	181.00	533.00	1.00	7.82	3.07
RS095397	262.00	1360.00	0.60	7.70	17.10
RS095398	222.00	936.00	39.00	7.84	13.80
RS095399	244.00	1000.00	0.20	8.03	24.80
RS095400	328.00	957.00	1.50	7.64	29.40

Evaluation of Gross Alpha and Uranium Measurements for MCL Compliance

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

IN THE MATTER OF:	)	
	)	
Alternative Lead in Drinking Water	)	VARIANCE UNDER
Reduction Treatment Technique	)	SECTION 1415(A)(3) OF
for Wisconsin Public Water Systems	)	SDWA
	)	
	)	

INTRODUCTION

1. Statutory and Regulatory Background

Under the Safe Drinking Water Act, 42 U.S.C. '' 300f-300j-26 (SDWA), U.S. EPA promulgates national primary drinking water regulations (NPDWRs), which specify for certain drinking water contaminants either a maximum level or treatment technique with which public water systems (PWSs) must comply. U.S. EPA has promulgated an NPDWR for lead and copper, the lead and copper rule (LCR), 40 C.F.R. Part 141, Subpart I, that consists of a treatment technique requiring PWSs to take various steps to ensure that users of their system are not exposed to levels of lead and/or copper in drinking water that would result in adverse health effects. The LCR requires all Community Water Systems (CWSs) and Non-Transient Non-Community Water Systems (NTNCWSs) to optimize corrosion control and to conduct tap water monitoring to ensure that lead and copper levels are minimized at users= taps. If tap water levels exceed either Aaction level@ (AL) of 0.015 mg/L for lead or 1.3 mg/L for copper, in more than 10 percent of drinking water tap samples (i.e., exceeds the AL as a 90th percentile value), PWSs are required to take additional steps, including delivering public education materials to users about the health risks of lead in drinking water (for lead AL exceedances), treating source water if it contains elevated lead and/or copper levels, or installing corrosion control treatment (CCT). For systems that continue to exceed the lead AL after optimizing CCT, the system must begin replacing at least seven percent of lead service lines (LSLs) in the system per year. LSLs that contribute less than 0.015 mg/L of lead do not need to be replaced and can be counted toward the number of LSLs required to be replaced.

The State of Wisconsin has primary enforcement responsibility for administering the LCR because it has adopted regulations that are at least as stringent as the federal regulations. *See* Wisconsin Administrative Code [INCLUDE CITATION]. The State regulation currently applies to all CWSs and NTNCWSs in Wisconsin.

U.S. EPA has the authority to grant a variance from any treatment technique upon a showing by any person that the alternative treatment technique is at least as efficient in lowering the level of that contaminant in drinking water. Section 1415(a)(3) of SDWA, 42 U.S.C. ' 300g-4(a)(3), provides:

> AThe Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance.@

See also 40 C.F.R. ' 142.46.

2. Factual Background

U.S. EPA and the Wisconsin Department of Natural Resources (WDNR) have agreed on the need to better integrate implementation of the statutory and regulatory requirements under the Clean Water Act (CWA)and Safe Drinking Water Act (SDWA) to protect public health and improve our nation's environment. Therefore, the U.S. EPA and WDNR have agreed to establish a more effective approach to reducing the lead levels in drinking water which would also reduce the phosphorus loadings in Wisconsin waters. The U.S. EPA and WDNR have concluded that successful projects demonstrate that in some cases, changes in U.S. EPA regulations, policies, guidance, or interpretations are needed to improve upon the nation's existing public health and environmental protection system. Where such changes can be made under existing law, U.S. EPA agrees to initiate the process for making the changes -- following applicable procedures.

The LCR requires that all systems optimize corrosion control to minimize lead and copper levels at consumers' taps. Many systems currently utilize orthophosphate as the primary lead and copper corrosion control mechanism and the addition of orthophosphate has been effective at reducing lead and copper levels in drinking water under the SDWA. The allowable discharge limits for phosphorus into receiving waters are being lowered under the CWA in Wisconsin such that the amount of orthophosphate being added as part of the Optimal Corrosion Control Treatment (OCCT) for SDWA compliance would require certain entities under the CWA to install treatment to remove the phosphorus prior to being able to discharge into receiving waters even where they have added none of the phosphorus themselves (e.g., entities using potable water in non-contact cooling water applications that is discharged to receiving waters). Almost all lead and copper comes from plumbing materials transporting drinking water to the homes via the distribution system and from plumbing within the homes themselves, therefore there is no possibility to remove these contaminants at the drinking water treatment plant.

A SDWA ban on the use of leaded solder and other leaded materials became effective in 1988 with subsequent additions and modifications to the law since then. It is no longer permissible to install most leaded materials in potable water applications within a public water system or premise plumbing. While the SDWA prohibits the introduction of most leaded materials into the plumbing network, it does not require the removal of existing lead sources. Lead service lines (LSLs), leaded brass and to a more limited extent leaded solder continue to leach lead into the drinking water, with the largest contributor overall being LSLs. The available options for effectively reducing lead and copper levels in PWSs with LSLs without the use of orthophosphate are very limited and could require significant additional water quality and operational changes, including capital improvements.

Many of the same entities regulated under both the CWA and SDWA must comply with lead in drinking water reductions under the SDWA and phosphorus discharge limits under the CWA. To accomplish this, a PWS with LSLs may be required to increase the level of orthophosphate necessary to control lead and copper corrosion at the drinking water plant and to also install treatment to remove the same orthophosphate they have added to the drinking water prior to being able to discharge into receiving waters under the CWA.

The Wisconsin Department of Natural Resources (WDNR) has proposed an alternative treatment technique for compliance with the LCR. WDNR believes that this alternative treatment technique will be more efficient than the LCR treatment technique in lowering lead and copper levels. WDNR proposes that this alternative treatment technique be allowed for certain Public Water Systems (PWSs) in Wisconsin that meet specific criteria. The alternative treatment technique specified in this variance contains a number of provisions, including the permanent removal of all LSLs, including all privately-owned portions of LSLs, within a PWS to lower the levels of lead in the drinking water, along with a corresponding re-evaluation of existing State OCCT designations, with the intent of modifying the State-designated OCCT to eliminate or reduce the level of orthophosphate addition to the water supply once all LSLs, including all privately-owned portions of LSLs, have been removed from the PWS.

U.S. EPA, Region 5, has reviewed WDNR=s proposal and believes that the proposal has merit and that the alternative treatment technique will be at least as efficient in lowering the level of lead and/or copper in drinking water as the existing treatment technique under the LCR.

U.S. EPA has identified a variance, pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. ' 300g-4(a)(3), as the appropriate legal mechanism for providing the regulatory flexibility which WDNR has requested. The variance allows certain PWSs to use the alternative treatment technique where specific conditions are met, in lieu of specific LCR requirements. The variance establishes participation criteria that a PWS must meet in order to qualify for the alternative treatment technique. The variance also sets forth the performance criteria that the PWS must meet to continue to be allowed to use this alternative treatment technique. To ensure that the alternative treatment technique is as effective as possible, and provides at least an equivalent level of protection as the existing regulations, U.S. EPA and WDNR have entered into a Memorandum of Understanding (MOU) describing the roles and responsibilities of each agency in implementing the variance. The MOU provides for oversight criteria, which WDNR will follow, to insure the proper implementation of the variance and the use of this alternative treatment technique.

FINDINGS OF FACTS

1. This matter comes before the Regional Administrator of U.S. EPA, Region 5, on request by WDNR, for a State-wide variance pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. ' 300g-4(a)(3).

2. Pursuant to Section 1401(4)(A)of SDWA, 42 U.S.C. ' 300f(4)(A), a PWS is a system that provides drinking water to the public for human consumption through pipes or other constructed conveyances, and that has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

3. A CWS is a PWS which serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents.

4. An NTNCWS, is a PWS that is not a CWS, and that regularly serves at least 25 of the same persons over 6 months per year.

5. Pursuant to Section 1401(1)(A) of SDWA, 42 U.S.C. ' 300f(1)(A), because CWSs and NTNCWSs are PWSs, certain NPDWRs apply to CWSs and NTNCWSs.

6. The LCR requires all CWSs and NTNCWSs to comply with the regulatory requirements specified at 40 C.F.R. ' 141.80 through ' 141.91.

7. WDNR requests that a State-wide variance be granted, allowing PWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in this variance in lieu of complying with specific regulatory provisions outlined in the LCR.

CONCLUSIONS OF LAW

1. Section 1415 (a)(3) of SDWA, 42 U.S.C. ' 300g-4(a)(3), and 40 C.F.R ' 142.46, authorize the Administrator to grant a variance from a treatment technique of an NPDWR:

   A...upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance.@

2. The authority to issue SDWA variances for treatment technique requirements was delegated to the Regional Administrators on June 12, 2000. Delegation 9-69, *Issuance of Variances for Treatment Technique Requirements*.

3. PWSs in Wisconsin will be eligible upon application to and approval by WDNR, for this variance only if all of the following conditions are satisfied:
   a. The PWS has signed a legally-binding agreement with the WDNR to remove all LSLs within the distribution system and including all privately-owned portions of any LSLs receiving water from the system, within no more than [15 years] from the date of such agreement, unless a lesser amount of time is specified by the WDNR.
   b. Any PWS with LSLs that receives water from another PWS which has agreed to participate in this variance must also agree to participate in this variance unless they are responsible for maintaining their own optimal corrosion control treatment.
   c. All participating PWSs must demonstrate to the satisfaction of U.S. EPA and the WDNR that they have the legal authority to require the removal of all LSLs, including all privately-owned portions of LSLs.

d. PWSs must agree to all terms and conditions outlined in section 4 of this variance, in the agreement established under this paragraph (3) of this variance.

e. [additional conditions]

4. The PWS must comply with all of the following requirements in this paragraph (4) in lieu of complying with the requirements specified in 141.80 through 141.82, 141.84, 141.86, 141.87 and 141.88. The requirements specified in this paragraph (4) constitute the alternative treatment technique:

   [CRITERIA TBD - EPA w/DNR INPUT]

5. The conditions specified in paragraph 3 and the requirements specified in paragraph 4 above, will be incorporated into individual agreements between WDNR and each participating PWS specified in paragraph 3.

6. The individual agreements will set the time frames for submitting assessments, demonstrations, sample results, designations, and other actions required by this variance, including any additional requirements specified by WDNR [alternatively, the timeframes can be specified in paragraph 4].

7. WDNR will review and act on all submittals in accordance with its existing PWS oversight program.

8. U.S. EPA and WDNR have entered into an MOU, which will become effective upon the finalization of this variance, and which describes each agency=s responsibilities regarding the variance and the alternative treatment technique.

9. Approval for the use of the alternative treatment technique for any PWS will be determined on a case-by-case basis by WDNR in accordance with the provisions of this variance and the MOU between EPA and WDNR.

ORDER

It is therefore ordered:

That in consultation with WDNR, the Regional Administrator, U.S. EPA, Region 5, finds that WDNR has made a showing for a variance under Section 1415(a)(3) of SDWA. WDNR=s request for a State-wide variance is granted, subject to the following conditions:

1. All participating PWSs meet the eligibility criteria outlined in paragraph 3 of this variance, above.

2. All participating PWSs meet the participation criteria outlined in paragraph 4 of this variance, above.

3. Failure to comply with any criteria in paragraphs 3 or 4 will automatically terminate the PWS= eligibility for this variance.

4. This variance shall terminate:

   d. Upon termination of the MOU by either WDNR or U.S. EPA; or

   e. Upon a determination by U.S. EPA or WDNR that the alternative treatment technique no longer provides the same level of public health protection as the requirements under the LCR.

5. In the event that the variance terminates, all PWSs subject to this variance shall be required to comply with all requirements under the LCR.

6. The Regional Administrator shall retain jurisdiction and shall annually review the circumstances pertaining to the variance, and may modify or revoke the variance if any provisions or conditions are not met.

7. Nothing in this Order alters or otherwise affects any requirement applicable under the State law.

Dated:_______________

____
Susan Hedman
Regional Administrator

LCR requirements for increased monitoring and long-term treatment change and/or new source addition

Increased monitoring based on AL exceedances

141.86(d)(4)(vi)
(A) A small or medium-size water system subject to reduced monitoring that exceeds the lead or copper action level shall resume sampling in accordance with paragraph (d)(3) of this section and collect the number of samples specified for standard monitoring under paragraph (c) of this section. Such a system shall also conduct water quality parameter monitoring in accordance with § 141.87(b), (c) or (d) (as appropriate) during the monitoring period in which it exceeded the action level. Any such system may resume annual monitoring for lead and copper at the tap at the reduced number of sites specified in paragraph (c) of this section after it has completed two subsequent consecutive six-month rounds of monitoring that meet the criteria of paragraph (d)(4)(i) of this section and/ or may resume triennial monitoring for lead and copper at the reduced number of sites after it demonstrates through subsequent rounds of monitoring that it meets the criteria of either paragraph (d)(4)(iii) or (d)(4)(v) of this section.

(B) Any water system subject to the reduced monitoring frequency that fails to meet the lead action level during any four-month monitoring period or that fails to operate at or above the minimum value or within the range of values for the water quality parameters specified by the State under § 141.82(f) for more than nine days in any six-month period specified in § 141.87(d) shall conduct tap water sampling for lead and copper at the frequency specified in paragraph (d)(3) of this section, collect the number of samples specified for standard monitoring under paragraph (c) of this section, and shall resume monitoring for water quality parameters within the distribution system in accordance with § 141.87(d). This standard tap water sampling shall begin no later than the six-month period beginning January 1 of the calendar year following the lead action level exceedance or water quality parameter excursion. Such a system may resume reduced monitoring for lead and copper at the tap and for water quality parameters within the distribution system under the following conditions:

Requirements for PWSs making long-term treatment changes and/or adding new sources

141.81(b)(3)(iii): This provision applies to PWSs deemed optimized by the State by virtue of having low lead levels (90th Pb percentile value – PQL <5ug/L) & meeting the Cu AL [with or without OCCT in place].

Any water system deemed to have optimized corrosion control pursuant to this paragraph shall notify the State in writing pursuant to § 141.90(a)(3) of any upcoming long-term change in treatment or addition of a new source as described in that section. The State must review and approve the addition of a new source or long-term change in water treatment before it is implemented by the water system. The
State may require any such system to conduct additional monitoring or to take other action the State deems appropriate to ensure that such systems maintain minimal levels of corrosion in the distribution system.

This provision applies to PWSs allowed by the State to reduce monitoring.

141.86(d)(4)(vii) Any water system subject to a reduced monitoring frequency under paragraph (d)(4) of this section shall notify the State in writing in accordance with § 141.90(a)(3) of any upcoming long-term change in treatment or addition of a new source as described in that section. The State must review and approve the addition of a new source or long-term change in water treatment before it is implemented by the water system. The State may require the system to resume sampling in accordance with paragraph (d)(3) of this section and collect the number of samples specified for standard monitoring under paragraph (c) of this section or take other appropriate steps such as increased water quality parameter monitoring or re-evaluation of its corrosion control treatment given the potentially different water quality considerations.

Preamble Language (LCR Minor Revisions – January 12, 2000)

(iii) *State discretion to impose additional requirements.*
(A) *Proposed revision and background.* The April 1996 proposed revision to § 141.81(b)(3) states: "The State may require any system deemed to have optimized corrosion control pursuant to this paragraph to conduct additional monitoring or to take other action the State deems appropriate to ensure that such systems maintain minimal levels of corrosion in the distribution system (*e.g.,* if there is a change in treatment or a new source is added)." EPA proposed this provision to provide States sufficient flexibility to require additional actions in those cases where such actions are necessary to ensure the system maintains minimal corrosion in the distribution system.

(B) *Comments and analysis.* Several commenters raised concern that this provision could require (b)(3) systems to conduct lead and copper tap sampling whenever treatment changes or a new source is added. The decision to require additional monitoring will be made by the State only after considering the impact of the treatment change or addition of a new source on the corrosion control process. The rule does not, and is not intended to categorically require monitoring when treatment changes are made. The additional monitoring is not limited to lead and copper monitoring. The State could require WQP monitoring and/or source water monitoring instead of, or in addition to, lead and copper tap monitoring.

(C) *Today's action.* EPA has included the following provision at § 141.81(b)(3)(iii). "Any water system deemed to have optimized corrosion control pursuant to this paragraph shall notify the State in writing pursuant to § 141.90(a)(3) of any change in treatment or the addition of a new source. The State may require any such system to conduct additional monitoring or to take other action the State deems appropriate to ensure that such systems maintain minimal levels of corrosion in the distribution system". EPA also has added a corresponding State recordkeeping requirement in a new § 142.14(d)(8)(ix).

j. *Requirements for systems subject to reduced monitoring that change treatment or source water.*

(i) *Proposed revision and background.*
In the April 1996 Proposal, EPA requested comment on a provision that would require water systems operating under reduced monitoring to report any changes in treatment or changes in source water to the State within 60 days. If the State believes the change merits additional monitoring, the State may require the system to resume standard monitoring, increase WQP monitoring, or re-evaluate its corrosion control and/or source water treatment given the potentially different water quality considerations. EPA proposed this requirement to help ensure that timely and appropriate action is taken to maintain optimal corrosion control when events occur that could significantly affect water quality.

(ii) *Comments and analysis.* Most commenters supported the proposed change. Several commenters thought the proposed rule was too general and should include more information describing a reportable treatment change. These commenters provided language to limit reportable treatment changes to those that affect the WQPs or interfere with the efficacy of the corrosion control strategy. EPA disagrees with these commenters. EPA does not believe that all systems understand the potential impacts of other treatments on corrosivity and, thus, is requiring that systems report all treatment changes to the State to avoid situations where systems could potentially overlook factors that influence corrosivity. The State will then review the treatment change and determine if additional monitoring or other action is necessary. EPA does agree, however, that it should not be necessary for the system to notify the State every time the system makes changes among approved sources of water. For this reason, today's action limits the reportable source water changes to those involving the addition of a new source of water. The only other major concern relayed by commenters is that some believe that water systems may be required to conduct unnecessary monitoring every time treatment is changed. EPA has addressed this issue in section C.1.c. of today's preamble as a part of the discussion pertaining to water systems deemed to have optimized corrosion control in accordance with § 141.81(b)(3).

Strategies to Obtain Customer Acceptance of Complete Lead Service Line Replacement

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Strategies to Obtain Customer Acceptance of Complete Lead Service Line Replacement

EXECUTIVE SUMMARY

AWWA supports replacement of lead service lines that significantly contribute to high lead levels in the home. Lead service lines can be a significant source of lead in tap water and, on the surface, complete lead service line replacement may be prudent. However, replacement is complicated by the ownership of the service lines. In some instances, the water utility owns the entire line. In others, the property owner owns the entire service line. And in still other cases, part of the service line is owned by the utility and part by the property owner. A public water system has no legal means to compel a property owner to replace a lead service line or portion of a lead service line. As a result, many water utilities that have replaced lead service lines have replaced only that segment that is under their control or ownership, in a practice commonly referred to as partial lead service line replacement.

Recent unpublished data indicates that partial lead service line replacements may substantially increase lead levels. A potential solution is replacement of the entire lead service line, an approach that often requires approval from the homeowner to replace their service line. Most customers are reluctant to agree to service line replacement on their property because of the cost, inconvenience and property damage that may result from the replacement procedure. This has caused utilities to develop innovative approaches to obtaining customer acceptance for complete replacement. This paper documents proven utility experiences with complete lead service line replacement.

Implementing a comprehensive lead service line replacement program targeting complete lead service line replacement can represent a major undertaking for many utilities. The specific costs will be site specific, depending on how extensive lead service lines were used in a public water system's service area, how existing distribution system maintenance procedures will need to be modified, how engaged the water system is in ongoing outreach programs with the relevant service areas, and other factors. Consequently, this document focuses on describing key elements of successful complete lead service line replacement programs so that readers can consider these elements when evaluating how to most cost effectively pursue local complete service line replacement program development.

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INTRODUCTION

Service line ownership is variable among water utilities. Examples of service line ownership include:

- the water utility owns the entire service line
- the property owner owns the entire service line
- part of the service line is owned by the utility and part by the property owner

In the partial ownership scenario, the configuration typically consists of a utility-owned segment that extends from the water main to a curb stop and a customer-owned segment that extends from the curb stop to the property owner's residence or building. An example of this configuration is illustrated in Figure 1.

Many of the service lines owned by utilities, principally those located in the Northeast and Midwest, are composed of lead piping. AWWA considers it to be prudent to replace lead service lines that contribute significantly to high lead levels in the home, in their entirety. As might be expected, property owners are generally reluctant to replace the service line on their property because of the cost, inconvenience and potential for property damage that can result from the replacement procedure.

The objective of this paper is to document the tools and practices that utilities are using to successfully overcome property owner reluctance and obtain property owner acceptance/investment for replacement of the lead service line on their property.

Overview

The issue of lead in drinking water has returned to the national spotlight after a decade of relative calm. Water utilities have generally been very successful in implementing effective corrosion control programs and in complying with the requirements of the Lead and Copper Rule. In spite of this, utilities are facing renewed regulatory, legislative and public scrutiny, attributable largely to the discovery of elevated levels of lead in the tap water in a few high profile communities.

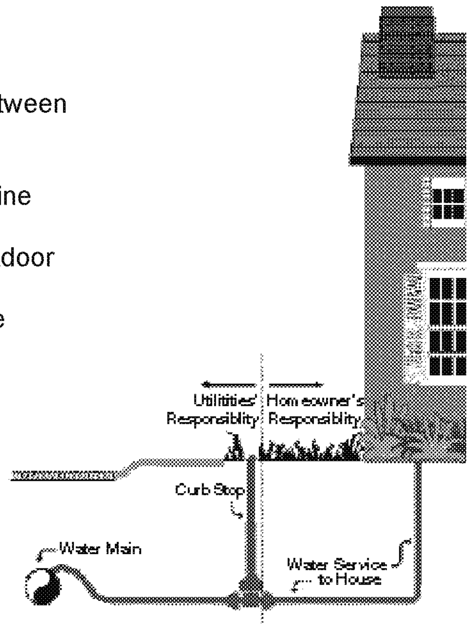
Recent unpublished data indicates that partial lead service line replacements may substantially increase lead levels. While many utilities have replaced the lead service lines under their ownership/control, it is prudent to consider replacement of the entire lead service line as a means to reduce exposure to lead in drinking water.

This document summarizes the regulatory requirements of the Lead and Copper Rule as it pertains to lead service line replacement. It documents the industry's service line replacement practices and presents a strategy to obtain customer acceptance of replacement of the lead service line on their property.

Figure 1 – Configuration of a Service Line with Partial Ownership by the Utility and Homeowner

Utility service line – the pipeline between the water main and the curb stop

Homeowner service line - the pipeline between the curb stop and the water meter. If the water meter is in an outdoor pit setting, the customer service line includes the pipeline extending to the building inlet.



REGULATORY REQUIREMENTS – THE LEAD AND COPPER RULE

Regulatory Background

The Safe Drinking Water Act (SDWA) is the legislation that addresses lead in drinking water. The Lead and Copper Rule is the specific regulatory mechanism designed to minimize lead in drinking water.

The Lead and Copper Rule (LCR), enacted into law in June 1991 and later amended in January 2000, applies to public water systems. Under the LCR, no more than 10 percent of tap samples from a targeted monitoring program conducted by a public water system may exceed the rule's Action Levels. The Action Levels specified in the LCR are 0.015 mg/l for lead and 1.3 mg/L for copper.

When the lead Action Level is exceeded, required follow-up steps include corrective action to implement optimized corrosion control and public notification. If a water system does not meet the lead action level, after installing corrosion control and/or source water treatment, then the system must replace at least 7 percent of the lead service lines in the distribution system annually. A system that does not replace the entire lead service line and that owns a segment of the service line must comply with notification, sampling and reporting requirements. A detailed summary of the Lead Service Line Replacement Requirements is provided in Appendix A.

Summary of Results from the Lead Service Line Survey

During the fall of 2004, AWWA funded Black & Veatch to conduct a survey of 65 water utilities to document lead service line management strategies and replacement techniques. Forty-one utilities completed the survey. Of the forty-one respondents, eleven provided detailed information on:

- Lead service line inventory and rates of replacement,
- Lead service line replacement costs,
- Forms of communications with customers,
- Financial incentives that are offered to customers,
- Mandatory lead service line replacement programs,
- Practices to minimize disruption to customers,
- Obstacles to implementation of a complete lead service line program, and
- Recordkeeping practices.

A summary of the survey responses from the eleven utilities is provided in Appendix B.

ELEMENTS OF A STRATEGY FOR CUSTOMER ACCEPTANCE OF COMPLETE LEAD SERVICE LINE REPLACEMENT

Gaining customer acceptance of lead service line replacement can be a challenging task. In addition to the disruptive nature of the replacement process, the cost and inconvenience that must be borne by the customer can be a very significant impediment. In spite of these obstacles, a number of utilities have implemented successful replacement programs. A feature common to each is an approach that incorporates elements of thorough preparation, financial incentives, effective public communications, follow-up interactions with homeowners and efficient recordkeeping practices.

Figure 2 presents a graphic summary of elements of a complete lead service line replacement strategy, based upon proven and documented utility experience. A menu of critical items and options is presented for each element of the strategy.

Getting Prepared

Thorough preparation is an essential first step in a lead service line replacement effort, particularly if the effort is to include service lines under customer ownership. Steps to consider include: development of a lead service line replacement strategy; securing economic resources coordination with other utility and public works departments; preparation of a communications strategy and communication with the State and Health Department. Each is described below with citations of relevant utility experience.

Development of a Lead Service Line Replacement Strategy

In order to define the scope of a lead service line replacement effort, it is useful to develop a strategy that takes into account the following:

- Public streets,
- Factors that influence the strategy,
- Design of the replacement program,
- Targeted replacement efforts,
- Partnering with established lead reduction programs, and
- Weather conditions

Following is a brief explanation of each item.

> *It is essential to coordinate lead service line replacement efforts with the departments responsible for public roadways.*

Public Streets

It is essential to coordinate lead service line replacement efforts with the departments responsible for public roadways. In doing so, the water utility can develop a replacement schedule that accounts for ordinances governing street-opening procedures, paving schedules, road improvement projects and similar infrastructure improvement activities.

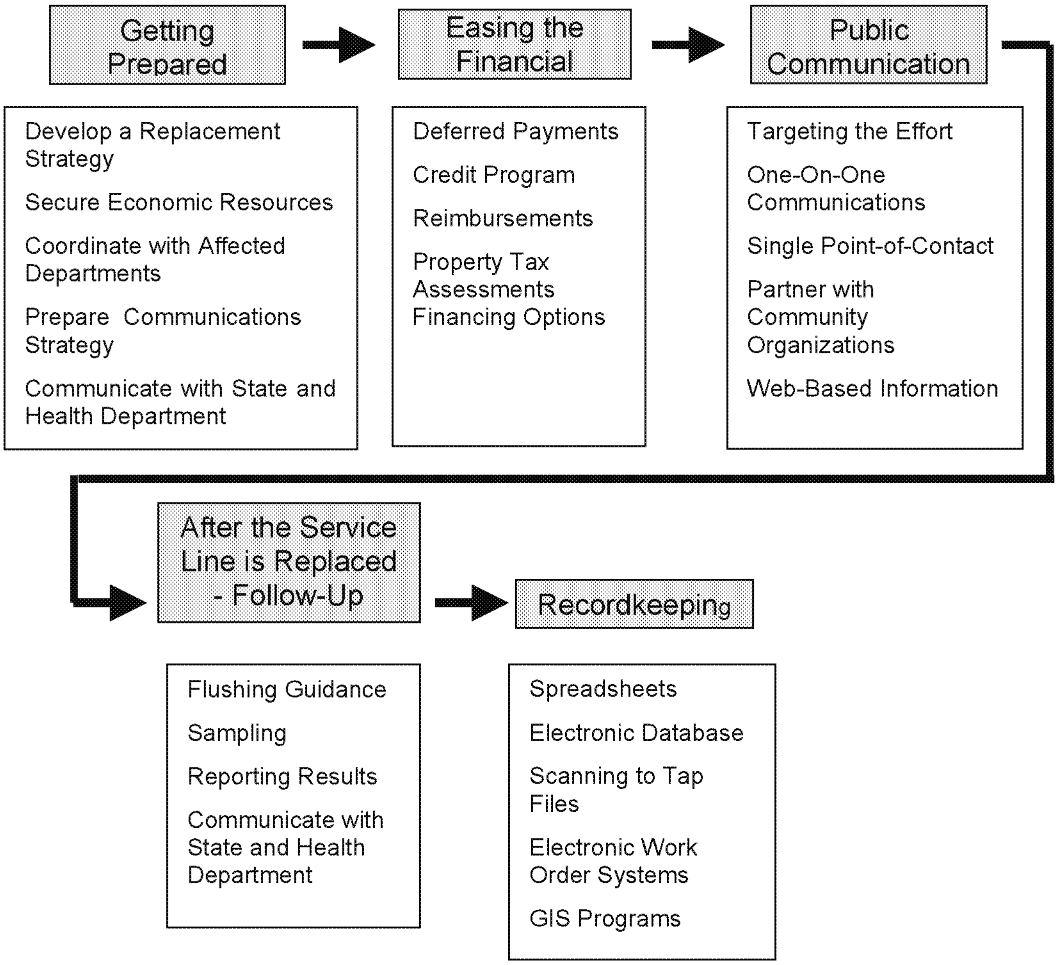


Figure 2. Elements of a Strategy for Complete Lead Service Replacement

Additional benefits include; avoidance of scheduling conflicts; implementation efforts that meet all local, state and federal ordinances/regulations; containment or reduction of costs that would otherwise be incurred if individual departments conducted the infrastructure improvements independent of one another; minimizing the frustration level of customers and the general public that utilize the roadways; and, the positive perception of a well coordinated, cost-effective infrastructure improvement program.

Factors That Influence the Strategy

A number of factors may have a bearing on the scope and implementation schedule of the lead service line replacement effort, such as:

1. Required Replacement - If removal of lead service lines is required for compliance with the LCR, the strategy must account for the requirement to replace at least 7 percent of the lead service line inventory in the distribution system, annually.

2. Quality of Utility Records-Depending upon the quality of the utility's records, the composition and condition of service lines may or may not be well understood. If records on service line composition and condition are inadequate, the utility may need to implement procedures to identify service line composition. Because these procedures can be somewhat labor intensive, utilities must account for this in planning the scope and cost of the

replacement program. In cases where the composition and condition of customer-owned service lines is unknown, the utility may suggest to homeowners that they perform a plumbing profile utilizing the services of a certified plumber or that they conduct a self-directed inspection of their service line to determine its composition. Appendix A includes a sample plumbing profile and an example of one utility's customer self-directed inspection program.

3. Service Line Ownership-Utility ownership of service lines varies throughout the country and, in many respects, dictates the level of customer support necessary for complete lead service line replacement. In cases where the utility owns the entire lead service line, the need for customer acceptance is minimal. In instances where the customer owns the entire lead service line, the utility must obtain customer agreement as a requisite step prior to replacement of lead service lines. The most common ownership scenario is partial utility ownership, generally between the water main and the curb stop. The customer owns the service line between the curb stop and the residence and replacement requires their agreement.

Design of the Replacement Program

In general terms, a utility can replace lead service lines either by incorporating the replacement activities into the broader service line renewal effort or by conducting a stand-alone replacement program. Data from the Lead Service Line Survey indicates that the majority of water utilities handle lead service line replacement as a component of the service line renewal effort associated with programmed replacements, routine maintenance, leak repairs, main replacements and street maintenance. A number of utilities described a dedicated lead service line replacement program that had been undertaken generally due to the sheer magnitude of the inventory of lead service lines or the need to meet a regulatory compliance schedule. The survey data indicate that both approaches have proven to be successful.

Utilities that incorporate lead service line replacement into their service line renewal program emphasize the need for well thought-out and thorough internal coordination as critical to a successful effort.

Targeted Replacement Efforts

A number of utilities participating in the Lead Service Line Survey identified high priority circumstances that warranted a targeted lead service line replacement effort. Examples include:

1. Sensitive Subpopulations - Buildings that house sensitive subpopulations (e.g. schools, child-care facilities) were designated a priority for lead service line replacement. Because these buildings are generally scattered throughout the distribution system, the utility must take into account the mobilization and manpower demands imposed by such a strategy.

2. Sites with Elevated Lead Levels - A number of water utilities have designed their replacement strategy to target the lead service lines of residences with elevated levels of lead in the tap water. As with Item 1 above, this places an added logistical burden on the crews tasked with implementing the replacement procedures.

3. Areas with Known Lead Challenges - Areas of the distribution system with a concentration of lead service lines (e.g. downtown centers in many older communities in the Northeast and Midwest) and segments of the distribution system subject to elevated corrosion rates (e.g. dead-ends, low-flow conditions) are examples of circumstances that may require targeted replacement efforts.

Well thought-out and thorough internal coordination is critical to a successful lead service line replacement effort

Partnering with Established Lead Reduction Programs

Many communities benefit from the efforts of organizations specifically established to deal with the issue of exposure to lead from sources other than drinking water. These organizations have recognized expertise in risk reduction and are generally perceived quite favorably in the eyes of the public. Partnering with these organizations can be very beneficial to water utilities and the communities that they serve. Such a partnership can lend considerable credibility to the utility's lead service line replacement efforts.

Weather Conditions Because lead service lines are most prevalent in the Northeast and Midwest, the replacement strategy must account for winter weather conditions that may either hinder replacement efforts or cause them to cease altogether, during extended periods of inclement conditions. In the City of Boston, for example, there is a moratorium on all street openings between November 15 and April 1, with the exception of emergencies. The replacement of lead service lines is not considered to be an emergency, unless the pipe is broken or leaking. Taking weather conditions into account is particularly important for utilities with mandated replacement quotas.

Securing Economic Resources

Implementing a comprehensive lead service line replacement program targeting complete lead service line replacement can represent a major undertaking for many utilities. The specific costs will be site specific, depending on how extensive lead service lines were used in a public water system's service area, how existing distribution system maintenance procedures will need to be modified, how engaged the water system is in ongoing outreach programs with the relevant service areas, and other factors. A challenge inherent in any major infrastructure improvement program is ensuring that adequate financial resources are developed and devoted to the project. In the case of a lead service line replacement program, the need for funding could potentially exist for a period of up to 15 years in duration.

The great majority of water utilities depend largely on the rates they charge customers to fund their operations and capital improvements. Most publicly owned water utilities operate as an enterprise fund within their municipal structure and thus rely on their own revenues and, frequently, on their ability to issue revenue bonds to fund capital improvements. Consequently, a major project, such as a program to achieve complete lead service line replacement, will normally result in increased customer rates to cover the costs of the program. A board, commission or City Council that oversees utility operations normally must approve financial matters such as budget approvals, rate increases and bond issues. In addition, the rates for most privately owned utilities and for some publicly owned ones are regulated by a state public utilities commission. Annual budgets and rates for most publicly owned utilities must be approved by a city council. So, obtaining a long-term commitment of funds for a complete lead service replacement strategy may be difficult and time consuming. It will require careful planning, information and education to convince decision makers and regulators that it is a priority that warrants funding and justifies rate increases.

Obviously, any funding a utility could obtain through grants or loans for a lead service replacement program would offset the need for funding the program internally. However, it is unlikely that sufficient grant money could be obtained to offset the entire cost of the program. One potential source of funding for lead service line replacement work is the Drinking Water State Revolving Fund (DWSRF). The DWSRF has been established to assist community water systems in achieving or maintaining compliance with SDWA requirements and furthering the public health objectives of the SDWA. The DWSRF is administered by State primacy agencies. In order to obtain the low interest loans available through the DWSRF, utilities must identify projects that rank sufficiently high within the primacy agency's priority system. As a general rule, projects designed to achieve compliance with SDWA requirements and protect public health, are ranked as highest priority. Therefore, if a utility must replace lead service lines to comply with the LCR, DWSRF funding may be available to the utility. Even if not required for LCR compliance, a compelling case can be made for reducing lead exposure from lead service lines as justification for DWSRF funding. It is recommended that utilities pursue DWSRF as a means to finance lead service line replacement programs. The DWSRF program, however, depends on annual federal budget allocations, and most states have far more demand for DWSRF assistance than funds available. So, even though an application may be well justified, there is no guarantee funds will be available from the DWSRF program. Providing that funds are available from the DWSRF program, a utility must still establish a rate schedule for repayment of the DWSRF loan.

As previously discussed, a lead service line replacement program preferably includes replacement of customer-owned lead service lines as well as utility- owned services. Replacement of customer-owned services may include financial investments or financial incentives provided by the utility. Funding of privately owned service line replacement may present an additional obstacle and difficulty for utilities. A public utility may be forbidden by state and local laws from conducting work on private property, as these general funds are typically restricted to a "public purpose". This in itself may prevent a utility from directly funding customer-owned lead service replacement unless a utility is able to define a public purpose for replacing privately owned lead service lines. In addition, only some portion of utility customers will have lead service lines and only some portion (maybe not the same customers) will have high lead levels. Yet, the utility may be asking all customers to help pay (through their rates) to resolve a problem that manifests itself directly at homes of relatively few customers. Funding of customer-owned lead service replacements is likely to trigger debate about the efficacy and equity of such action and the public benefit that will accrue from it.

One utility faced with this difficulty obtained city council approval, after much debate, for a financial program that reimburses customers who replace their lead service lines for one-half the cost of replacement up to a maximum of $1,000. The utility argued that replacement of customer lead service lines was needed in order for the utility and the city to gain compliance with federal regulations. The reimbursement program was established in lieu of direct replacement of service lines to avoid the prohibitions and liabilities of conducting work on private property. In this particular case, replacement of lead service lines would allow the utility to avoid significant drinking water and wastewater treatment costs that would otherwise have caused increases to the water and sewer rates of all utility customers. The utility justified investment in replacement of customer-owned services by documenting direct costs that could accrue to all utility customers and less quantifiable ancillary costs that could accrue to the community as a whole if lead service lines were not replaced. A compromise of providing customer reimbursement for one-half the cost of replacement was made in recognition that replacement of the service lines provides a benefit to the utility and city as well as providing a benefit to the individual customer whose service line is replaced.

Securing economic resources for a comprehensive and, possibly, long-term lead service line replacement program is going to be a challenge for utilities. Utilities and cities can continue to work for federal grants for this purpose or for infrastructure improvements in general and can continue to lobby for funding for the DWSRF. Lead service replacement in areas of low and moderate income families may be funded through community development funds or by a city or town agency other than the water department. If direct city action on private property is prohibited, rebates or bill reductions for lead service replacement may be allowable. A "betterment charge" may be way to effectively loan the money to homeowners reducing their upfront cost. If general obligation or revenue bonds cannot be used on private property, some jurisdictions may be able to borrow from commercial sources, and recoup the payments from homeowners as a special charge.

Good information, communication and planning are essential to obtaining approvals for funding lead service replacement programs.

In the City of Boston, a street is designated as "guaranteed" once it is paved, prohibiting excavation for a period of five years. Coordination between the Boston Water & Sewer Commission and the City's Street's department is essential to ensure that service line replacement occurs prior to planned paving efforts.

Coordination with Other Public Works Departments and Jurisdictions

Lead service line replacement generally involves excavation in public roadways, making it essential to coordinate the replacement effort with the departments responsible for public roadways as well as other utilities that may have underground structures, pipelines, cables, etc buried in proximity to the utility's water mains and service lines. Because many water utilities serve multiple communities, it is important to extend coordination efforts to the public works departments in all affected jurisdictions.

Significant constraints can be imposed upon the replacement effort by ordinances that govern street-opening procedures. For example, in the City of Boston, when a street is paved, it is designated as "guaranteed". Except in an emergency, excavation is prohibited for a period of five years. Coordination between the Boston Water & Sewer Commission and the City's street's department is essential to ensure that service line replacement occurs prior to planned paving efforts. Several utilities responding to the lead service line survey reported a similar requirement for coordination between public works departments.

Prepare a Communications Strategy

Upon finalizing the logistics of the replacement program, development of a communications strategy follows from the replacement strategy. The goal of the communication plan is to obtain cooperation and acceptance from customers / property owners for complete lead service line replacement. Specific communication tools are identified in a subsequent section of this report.

Communication with the State and Health Department

Keeping an open line of communication with the state and the local health department prior to and throughout the replacement program is advisable. In some cases, this communication is required by the LCR (in situations where the action level was exceeded and lead service line replacement is mandated). A significant benefit of involving regulatory and health officials early-on in the process is that they are perceived as experts in the eyes of the public from a regulatory and health standpoint. Given the volatile nature of the concerns with lead in tap water, support for the utility's lead service line replacement program by regulatory and health authorities adds credibility to the process.

The most significant barrier to acceptance of lead service line replacement is the expense that must be borne by the homeowner.

Easing the Financial Burden

The most significant barrier to acceptance of lead service line replacement is the expense that must be borne by the homeowner.
In an effort to ease the financial burden, a number of utilities have developed financial incentive packages that are offered to their customers. In some cases, the customer can take advantage of either a single incentive offering or a combination of incentives. One utility has developed an offering for homeowners in low-income situations.

Specific examples of incentive offerings include:

- Low-income deferred payment program – For customers who meet specific "low-income" criteria, the utility pays a certified plumber, on behalf of the customer, for replacement costs. The debt to the utility is placed as a lien against the customer's property and accrues interest at a pre-determined rate.

The customer has the choice of making payments on the debt in any amounts he/she deems affordable or of deferring any or all payment on the debt until the property transfers ownership. The utility has found this "low-income" program particularly attractive for elderly customers on a fixed income who anticipate selling their home and moving to senior housing or assisted-living in the foreseeable future.

- Providing credit to a certified plumber – A specified amount of credit is offered to a certified plumber of the customer's choosing, to offset the cost of replacing the service line. Typical values for the credit amount range from $1,000 to $1,500. The customer is responsible for any costs over and above the established credit amount. In the case of one large utility, the balance due can be charged to the owner's account for repayment over a 24-month period with no interest charges accrued over the repayment period.

- Customer reimbursements – Following replacement of the service line by a certified plumber, the utility reimburses the customer for one-half of the replacement cost. A "not to exceed" value can be established or the utility may waive such a value altogether. A typical "not to exceed" reimbursement value is $1,000.

- Property tax assessment - The property taxes of the homeowner are reduced by an amount equivalent to the replacement cost, via a one-time tax assessment.

- Financing the cost of replacement – The customer can finance the cost of the service line replacement via a low-interest rate loan offered by the utility. A 4% interest rate is one example identified in the lead service line survey.

Make it easy for the homeowner to take advantage of the financial incentives that have been offered. Provide the homeowner with simple, specific information about the terms of the incentive program

By offering financial incentives, a utility can often overcome the most difficult barrier to customer acceptance of replacement of their lead service line. Utilities that have implemented successful incentive programs offer the following sound advice: Make it easy for the homeowner to take advantage of the financial incentives that have been offered. Provide the homeowner with simple, specific information about the terms of the incentive program including: the amount of money involved in the transaction, repayment terms, interest rates, impact on their credit standing and property lien details, if applicable.

Governing board acceptance is a key step in implementing incentive programs. Involving governing boards in development of any incentive program can facilitate approval. In the case of private utilities, authorization by regulatory authorities is necessary prior to offering the incentives to property owners.

Mandatory Lead Service Line Replacement Programs - As previously mentioned, water utilities generally do not have control over service lines on private property or downstream of the curb stop or shut-off valve. In addition, there are usually legal prohibitions, restrictions and/or liabilities associated with a utility working on private property or issuing a public works contract for such work. Consequently, most utilities that implement programs for replacement of customer-owned lead service lines are limited to providing education, encouragement and incentives to customers. Ultimately, the decision on whether or not to replace a lead service line on private property rests with the customer.

In two instances, however, a utility or city has mandated the replacement of lead service lines on private property. In one case, the utility was in the rather unique position of owning the service line extending from the water main in the street to the water meter in the customer's home. As owner of the service line on private property, the utility had the authority to replace the entire service line. Access into the customer's home for the express purpose of service line replacement was a condition of service. If the owner were to deny access, the utility could disconnect water service to the property. Since the utility owned the entire service line, there was no financial obligation to the customer for the cost of service line replacement.

Another utility exceeded the lead Action Level and was unable to establish optimized corrosion control with best available treatment techniques, owing to a number of unique circumstances. In order to comply with the LCR, the utility proposed to replace its lead service lines in lieu of chemical treatment. The primacy agency regulating the utility determined it could only accept lead service replacement as a substitute for corrosion control treatment if the utility ensured replacement of both the utility-owned and customer-owned portions of lead service lines. Since the utility could not legally work on private property or issue contracts for work on private property, the utility sought and obtained a City ordinance that required customers to replace their lead service lines. In conjunction with this mandated replacement program, the utility administers a reimbursement program that pays customers for half the cost of replacement up to $1,000. The utility also has an additional financial program for low-income customers.

While both approaches have proven to be successful for the respective utilities, the circumstances facing each were unique. Due to private ownership, property rights and other legal issues, mandated programs for replacement of customer lead service lines are particularly difficult to implement and will not likely be pursued except in the most extreme cases when other alternatives are not available. These cases, however, illustrate the extent of actions utilities have taken given their specific circumstances.

Public Communications

"Do not embark on a lead service line replacement project without thoroughly and broadly educating the public on the issue. Merely informing them through written media and the Consumer Confidence Report is not sufficient." This is the advice offered by a large utility that has implemented a successful service line replacement program.

Utilities have employed a wide variety of tools to inform homeowners about lead service line replacement, ranging in scope from one-on-one communications to general outreach to the entire community. These tools have varying levels of effectiveness in getting their intended message across to the target audience. Effective communication efforts on lead service line replacement have been both informative and persuasive in order to gain homeowner acceptance for replacement of the service line on their property. With that in mind, the matrix presented in Table 1 summarizes the various forms of communications commonly used by utilities and provides an assessment of the likely effectiveness of each, in the context of achieving customer acceptance of replacement of lead service lines.

One-on-one communication between the utility and homeowner has proven to be very successful in gaining acceptance of replacement of lead service lines

As noted above, a targeted communications effort is more likely to result in homeowner acceptance of lead service line replacement on their property than a general outreach approach. In particular, one-on-one communication between the utility and homeowner, or the homeowner's plumber, has proven to be very successful. One large utility participating in the lead service line survey cited a 90 percent success rate resulting from one-on-one contact with homeowners.

By clearly communicating the purpose for action and immediately offering concrete actions that homeowners can take, outreach efforts can effectively reach affected homeowners. Programs which create a sense of anxiety about the quality of the water, without offering the consumer a way to resolve the problem, are counterproductive. Programs that create a sense of need and identify

Table 1. Anticipated Effectiveness of Selected Communications Options

Medium	Option	Anticipated Effectiveness
One-on-One Contact	Utility staff (e.g. inspector, field service representative) meets with property owner on individual basis	High
	Utility representative works directly with plumber hired by property owner	Low-Moderate
Partner with Community-Based Organization(s)	Utilize communications and outreach expertise of the Organization(s)	High
Web-Based Information	Utility website with information about lead service line replacement	Moderate-High
	Internet information about lead	Moderate
Telephone Contact	Utility contacts property owner by telephone to discuss service line replacement	Moderate
Public Meetings	Public meetings/hearings to provide forum for information exchange	Moderate
Written Correspondence	Door Hangers/Postcard affixed to door	Moderate
	Bill inserts with information about lead service line replacement	Low
	Consumer Confidence Report – section devoted to lead	Low
	Direct Letter to homeowner	Low
Mass-Media	Television-news items, public service announcements about service line replacement	Low
	Newspaper-articles and notices about service line replacement	Low

corrective actions, but do not offer the immediate opportunity for action, are also unlikely to be effective. Consumers have many demands on their time and attention and may quickly move beyond the issue of lead service line replacement. This is one reason why efforts, such as direct outreach, where a staff person speaks to the customer in their home have the highest success rate.

Designing a Communications Plan

Effective communications plans have tangible goals, like:

- Specific plans and objectives for efforts to reach specific audiences such as those neighborhoods with a high density of lead service lines or homes with known lead service lines and elevated levels of lead in the tap water

- Identify specific elements of one-on-one communication with homeowners
- Include mechanism for ongoing communication, such as designating a certified plumber of the utility's (or customer's choosing) to act as the point of contact.

Community-based organizations dedicated to the goal of reducing exposure to lead can be an influential partner in the utility's efforts to replace lead service lines

Managing community lead exposure has a long history in many communities. Consequently there are existing community organizations that can aid in outreach efforts on lead. When implementing the communications plan, the utility can consider availing itself of the expertise and established presence of these organizations. Such partnerships have proven successful when dealing with homeowners and the general public.

The popularity of the Internet affords an opportunity to provide details about lead service line replacement in the utility website. For example, the Madison (Wisconsin) Water Utility website provides information about lead exposure, lead service line replacement, helpful procedures for customers and contact listings. The Madison site is an example of effective web-based communications. It can be accessed at: http://www.madisonwater.org/leadindex.html

Following service line replacement, customers will need easily-understood flushing directions. This guidance is an instance to emphasize the importance of flushing after any significant period of stagnation.

In summary, a targeted communications plan characterized by repetition and conducted with the assistance of community-based organizations can be quite effective in gaining acceptance of lead service line replacement on the homeowner's property.

AwwaRF will be releasing Strategic Communication Planning: A Guide For Water Utilities by early 2006. This report will provide practical advice on managing and budgeting public communication efforts such as the one needed to support a complete lead service line replacement effort.

After the Service Line Has Been Replaced – Follow-up Actions

There are a number of follow-up actions to keep in mind upon completing replacement of the service line. These include:

1. Communication with the homeowner about flushing procedures and managing post-replacement lead levels - Lead levels have a tendency to become elevated for a temporary period of time following service line replacement. Easily-understood flushing directions can help homeowner's minimize any exposure during this period. Emphasis should be placed upon the importance of following the instructions after any significant period of stagnation.

   Utilities may wish to consider providing bottled water, bottled water vouchers, instructions on the types of water filters that a homeowner may want to purchase, or provide a filtering device (e.g. a pitcher filter or household filter) to the property owner during this interim period.

2. Follow-up samples - If lead service line replacement is required for compliance with the LCR, the water system must collect a representative sample from each replaced lead service line within 72 hours of

completion of the replacement. In cases where lead service line replacement is not mandatory, the utility may choose to conduct follow-up sampling to determine if lead levels in the tap water are below the lead action level. A utility can also advise homeowners about how to take samples of lead and explain local options for obtaining sample analyses.

It is important to note that the sampling procedures for determining the lead contribution from a service line are different from the procedure for first draw samples. Service line sampling procedures are outlined in Appendix A (pages 20 and 21). Further, caution should be exercised in interpreting the data from service line samples. A single sample result may not be representative of the true contribution to lead levels resulting from service line replacement. As such, it may be prudent to collect a series of samples over a defined period of time in order to accurately gauge the trend in the behavior of the lead levels after a lead service line replacement.

3. Providing results to the homeowner - Results from samples collected as a requirement for LCR compliance must be reported to the owner and resident(s) within 3 business days of receiving the results from the laboratory. Likewise, in cases where the utility has conducted non-compliance sampling, customers expect information on observed levels in a timely manner, particularly if the results suggest elevated lead levels.

4. Communications with the State and Health Department - Water systems that are required to replace lead service lines for LCR compliance must provide a copy of post-lead service line replacement results to the State within the first 10 days of the month following the month in which the results are received from the laboratory. Individual state primacy agencies have different expectations for handling non-mandatory sample results. Likewise, some local health departments find this type of information informative. Discussing agency needs and expectations for this data can facilitate communication with these agencies.

5. Additional Sources of Information - There is a wealth of information available about lead in drinking water that can be offered to customers who wish to obtain more specific information. A listing of recommended resources is provided in Appendix E.

Recordkeeping

Accurate and timely recordkeeping is an essential element of a lead service replacement effort. In addition to satisfying compliance requirements of the LCR, if necessary, comprehensive records enhance the utility's capability to respond to concerns of the public, the media and regulators. The records also provide an accurate accounting of service line composition in the event that it is necessary to access that information in the future.

In some instances, obtaining the data necessary for complete and accurate records will require coordination with other departments within the utility and/or other public works departments. It is important to clearly describe the recordkeeping design and data capture responsibilities of each department prior to initiation of the service line replacement effort. A periodic review of data capture procedures and the quality of data is important to assuring that data collection practices are indeed working smoothly and a sound data set is generated and maintained.

A summary of the range of recordkeeping practices employed by utilities is presented in Appendix B on page 18.

SUMMARY

Complete lead service line replacement may represent a significant challenge for water utilities because of complicated ownership issue. In cases where part of the service line is owned by the utility and part by the property owner, a utility that seeks to replace the entire lead service line must obtain permission from the homeowner/property owner to do so.

A number of utilities have implemented successful complete lead service line replacement programs. This document draws upon the experiences of those utilities and presents the elements of a strategy to obtain property owner acceptance for complete lead service line replacement.

Appendix A. Requirements of the Lead and Copper Rule Pertaining To Lead Service Lines

If a water system does not meet the lead action level, after installing corrosion control and/or source water treatment, then the system must replace at least 7 percent of the lead service lines in the distribution system annually. A system is not required to replace an individual lead service line if the lead concentration, in all samples from that service line, is less than or equal to 0.015 mg/L.

A water system is required to replace only the segment of the lead service line which it owns. In situations where the water system does not own the entire lead service line, the system must notify the property owner (or the owner's authorized agent) that the water system intends to replace the lead service line and must offer to replace the property owner's portion of the service line. Water systems are not required to bear the cost of replacing the property owner's service line nor are they required to replace that segment if the owner chooses not to pay the cost of replacement.

A water system that does not replace the entire lead service line and owns a segment of the service line must comply with the following:

a. Notification to Residents
   At least 45 days prior to partial replacement of the lead service line, the water system must notify the residents of all buildings served by the lead service line that they may experience a temporary increase in the lead levels in their drinking water. Guidance on measures that can be taken to minimize exposure to lead must also be provided at that time. The notification requirements can be satisfied by a direct mailing or other means approved by the State. In instances where multi-family dwellings are served by the lead service line, the water system has the option of posting the information in a conspicuous location.

b. Sampling and Reporting Requirements
   The water system must inform residents served by the lead service line that the system will collect a representative sample from each partially-replaced lead service line within 72 hours of completion of the replacement. The system must report the results of the analysis to the owner and resident(s) served by the lead service line within 3 business days of receiving the results from the laboratory. The cost of the sampling and analysis must be borne by the water system.

   Each service line sample shall be one liter in volume and have stood motionless in the lead service line for at least six hours. Lead service line samples shall be collected in one of the following three ways:

   1. At the tap after flushing the volume of water between the tap and the lead service line. The volume of water shall be calculated based on the interior diameter and length of the pipe between the tap and the lead service line.
   2. Tapping directly into the lead service line, or
   3. If the sampling site is a building constructed as a single-family residence, allowing the water to run until there is a significant change in temperature which would be indicative of water that has been standing in the service line.

c. Reporting Post-Lead Service Line Replacement Results to the State

> Water systems must provide a copy of post-lead service line replacement results to the State within the first 10 days of the month following the month in which the results are received from the laboratory. States have the authority to modify or eliminate this reporting requirement.

States have the authority to require a water system to replace lead service lines on an expedited schedule. The State must make this determination in writing and notify the water system of its findings within 6 months after the system is triggered into mandatory lead service line replacement.

Water systems may cease replacing lead service lines, with State acceptance, when water samples collected to measure the lead contribution from lead service lines, meet the lead action level during each of two consecutive monitoring periods. Subsequent water samples that exceed the action level require the water system to recommence replacing lead service lines.

Additional information about the LCR is available on the EPA Office of Ground Water and Drinking Water's website at: http://www.epa.gov/safewater/lead/index.html

Appendix B. Summary of Results from the Lead Service Line Survey

Lead Service Line Inventory and Rates of Replacement

Presented in Table 1 is a summary of the inventory estimates of utility-owned lead service lines in 1992 and 2003 with the corresponding percent reduction attributable to service line replacement. Also provided is a qualifying statement as to the confidence level associated with the accuracy of the estimates. Table 2 presents similar information for customer-owned lead service lines. The utility numbers are consistent for both Tables 1 and 2.

Table 1. Estimated Inventory of Utility-Owned Lead Service Lines

Utility No.	1992 Lead Service Line Inventory	2003 Lead Service Line Inventory	Percent Reduction, %	Confidence in Inventory Estimate
1	36,000	20,000	44	High
2	9,000	3,300	63	Medium - High
3	283,000	280,000	1	Low
4	unknown	0	n/a	Low
5	10	0	100	High
6	0	0	0	High
7	1,000	200	80	Medium
8	unknown	0	n/a	Low
9	unknown	62	n/a	Low
10	7,000	3,100	56	High
11	12,744	11,351	11	Medium

Table 2. Estimated Inventory of Customer-Owned Lead Service Lines

Utility No.	1992 Lead Service Line Inventory	2003 Lead Service Line Inventory	Percent Reduction, %	Confidence in Inventory Estimate
1	36,000	20,000	44	High
2	15,000	5,800	61	Medium - High
3	unknown	unknown	n/a	Low
4	unknown	unknown	n/a	Low
5	1,250	800	36	High
6	unknown	unknown	n/a	Low
7	400	300	25	High
8	unknown	unknown	n/a	Low
9	unknown	unknown	n/a	Low
10	7,750	2,600	66	High
11	5,455	5,227	4	Medium

More recent data, representing the replacement of lead service lines in 2002 and 2003, is presented in Tables 3 and 4, respectively. The utility numbers are consistent for both Tables 3 and 4.

Table 3. Utility and Customer-Owned Lead Service Lines Replaced in 2002

Utility No.	No. of Utility-Owned Lead Service Lines Replaced	No. of Customer-Owned Lead Service Lines Replaced
1	2,000	2,000
2	680	820
3	250	Unknown
4	746	Unknown
5	0	15
6	0	18
7	400	10
8	0	6
9	Unknown	Unknown
10	539	642
11	150	190

Table 4. Utility and Customer-Owned Lead Service Lines Replaced in 2003

Utility No.	No. of Utility-Owned Lead Service Lines Replaced	No. of Customer-Owned Lead Service Lines Replaced
1	2,000	2,000
2	272	375
3	250	0
4	700	0
5	0	10
6	0	20
7	400	10
8	0	6
9	402	75
10	746	700
11	162	193

Of the 11 utilities, 6 had components of a specifically-designed lead service line replacement program. The others replace lead service lines as-needed or coincident with another construction project such as main replacement or street paving.

Lead Service Line Replacement Costs

Presented in Table 5 is a summary of the costs incurred to replace utility and customer-owned lead service lines. The utilities were asked to include the costs associated with mobilization, replacement and restoration.

The utility numbers are consistent with those presented in Tables 1-4. A descriptor is provided to characterize the nature of the replacement effort, whether it be a specifically designed replacement program or as-needed/coincident with construction projects

Table 5. Summary of Lead Service Line Replacement Costs

Utility No.	Utility-Owned Lead Service Line Replacement Costs	Customer-Owned Lead Service Line Replacement Costs	Nature of Replacement Program
1	$1,150	$1,150	as-needed / incidental / designed
2	$1,500	$2,000	designed
3	$1,000 - $1,500	$1,000 - $10,000	as-needed / incidental
4	$2,500	not provided	incidental
5	not provided	$450 - $2,500	as-needed / designed
6	not provided	$1,200	designed
7	$800	not provided	as-needed / incidental
8	not provided	$4,000	incidental
9	$3,200	not provided	incidental
10	$2,000	$1,400	designed
11	$1,650	$1,450	designed

Public Communications

Examples of the various forms of communication employed by utilities to inform customers about lead service line replacement include:

- Direct mailings and letters explaining lead service line replacement
- Direct mailings and letters seeking customer acceptance for replacement of the service line on the customer's property. Typically, this correspondence is sent to the customer several months in advance of replacement activities and again just prior to the date of replacement. Sample letters are provided in Appendix D.
- Distribution of brochures containing facts about lead and health and steps to minimize exposure to lead
- Distribution of brochures that explain lead service line replacement techniques and customer flushing procedures following completion of the service line replacement
- Bill inserts with facts about lead and health effects

- One-on-one visits to individual customers by utility personnel. This is reported to have a 90 percent success rate in obtaining customer acceptance for service line replacement.
- Media coverage (television and newspaper) of the lead service line replacement program and the risks posed by exposure to lead.
- The annual Consumer Confidence Report
- Public meetings/hearings
- The utility website with specific information about lead and the lead service line replacement program

Financial Incentives

Examples of financial incentives offered to customers to offset the economic burden of lead service line replacement include:

- Reduction of the homeowner's property taxes in an amount equivalent to the service line replacement cost, via a one-year assessment.
- Financing of the replacement cost at a special interest rate.
- A $1,000-$1,500 credit toward the cost of replacement of the service line. The owner is responsible for any costs over and above the credited amount. The balance owed can be charged to the owner's account for repayment over a 24 month period with no interest accrued.
- Reimbursement to the homeowner for one-half the cost of the replacement. Some utilities have established a $1,000 reimbursement limit while others have not set a limit.
- Utility payment of the plumber that performs the service line replacement. The customer is obligated to repay the utility over an agreed-upon period of time. A lien is established against the owner's property under this option.

Mandatory Lead Service Line Replacement

Two utilities reported on mandated replacement of lead service lines on private property:

- One utility owns the entire lead service line. Access into the customer's home for the express purpose of service line replacement is a condition of service. Should the owner not grant access, water service can be discontinued to that property.
- One utility sought and obtained a City ordinance that required customers to replace their lead service lines. In conjunction with this mandated replacement program, the utility administers a reimbursement program that pays customers for half the cost of replacement up to $1,000. The utility also has an additional financial program for low-income customers.

Practices to Minimize Disruption to Customers

Practices and procedures to minimize disruption resulting from service line replacement include:

- Use of trenchless technology to minimize property damage and duration of interruption of service
- Providing bottled water upon request from the customer

- Performing replacement at a convenient time for the customer
- Communicating directly with the customer's plumber to avoid confusion and logistical issues
- Providing post-replacement flushing and maintenance guidance

Obstacles to Implementation of Complete Lead Service Line Replacement

Cited obstacles to complete lead service line replacement include:

- Difficulty in establishing service line replacement as a priority expenditure within the utility's capital investment program
- Competition for economic resources within the water utility
- Maintaining continuity among utility departments to keep accurate records and employ consistent replacement procedures
- Difficulty in coordinating replacement efforts with the City's paving plans
- Difficulty in coordinating the replacement effort among affected branches of public works departments and utilities
- Lack of accurate records on the composition of service line materials
- Repetitious work performed in a specific area (e.g. repaving a street each time that utility work occurs)
- Prohibitive repaving costs
- Targeted replacement of lead service lines at buildings with sensitive subpopulations requires crews to move sporadically throughout the distribution system, introducing labor deployment inefficiency.
- Lack of clarity of the Lead and Copper Rule
- Difficulty in explaining the concept of action levels as compared to MCLs
- Lack of a definitive link between lead levels in drinking water and health effects
- Negative public perception of the intrusion associated with service line replacement

Recordkeeping Practices

Recordkeeping procedures associated with service line replacement include:

- Designing and maintaining a spreadsheet of service line inventory and composition
- Maintaining an electronic database of service line inventory
- Recording new service line locations and scanning locations into a tap card file
- Updating of electronic work order systems by utility crews and contracted plumbers as service line replacements are completed
- Incorporation of service line locations/replacements into a GIS program
- Tracking of costs (i.e., a work order system for in-house work and invoices for contract work)
- Integration of an electronic database of service line information with an AM/FM/GIS system

Appendix C. Sample Plumbing Profile

The following questions and corresponding explanations may assist in identifying the composition and condition of a customer's service line or other home plumbing. It may be advisable to consult a local plumbing expert in order to accurately answer the questions.

Question: When was the facility constructed?

Significance: While the dates may vary from one community to another, generally buildings constructed through the early 1900s commonly used lead interior pipes. Plumbing before 1930 is most likely to contain lead. Between 1920 and 1950, galvanized pipes were used for interior plumbing. After 1930, copper generally replaced lead as a service line material. Up until the late 1980s, lead solders were typically used to join copper pipes. The lead-free requirements of the 1986 Safe Drinking Water Act banned lead solder with more than 0.2% lead and plumbing with more than 8% lead. Buildings did not have to be built with certified "lead-free" fixtures until 1997

Question: What material is used in the service line?

Significance: Historically lead piping was used in some communities for service lines that join buildings to public water supplies. Lead pipes are dull gray in color and may be easily scratched by a metal object. Lead pipes can be a source of lead contamination. Galvanized pipes are gray and usually fitted together with threaded joints. Copper pipes are red-brown in color. Corroded portions may show green deposits. A refrigerator magnet will stick to galvanized pipe but not to lead or copper pipe.

Question: Do faucet screens collect metallic particles?

Significance: Lead-containing sediments trapped on screens are an indication that there is corroded lead pipe in the plumbing system that can be a source of contamination. Testing can determine whether the sediment contains lead. Cleaning screens frequently reduces exposure if there is lead in sediment trapped there..

Question: Are there other signs of corrosion?

Significance: Corrosion may indicate high levels of lead, copper and iron in the water.

Question: Is electrical equipment grounded to water pipes?

Significance: Electric current traveling through the ground wires may accelerate the corrosion of interior plumbing containing lead. DO NOT remove the wires from the pipes unless a qualified electrician installs an alternative grounding system. Improper grounding of electrical equipment may cause severe shock.

Question: Has a tap water sample tested positive for lead?

Significance: Results of testing for lead can provide clues about the materials of construction in the residence and the resulting impact on lead levels in the water. If the answers to other questions in this profile indicate a potential for a lead service line or home plumbing, it is strongly advised to test the water for lead levels. The validity of lead testing in water depends on following a strict protocol of sampling techniques. Contact your water utility or testing lab to ensure that proper sampling protocol is followed.

Customer Self-Directed Lead Service Line Inspection Program

Madison Water Utility in Wisconsin implemented a ten-year program of complete (customer and utility) lead service line replacement in 2001. While the Utility had good records of the location of utility-owned lead service lines, its records of the location of lead on the customer side of the service were sporadic at best. Knowing that the Utility and area plumbers stopped using lead as a service line material about 1928, the Utility sent an inspection survey form to the owners of all properties developed before that time period. The Utility required owners of such properties to self-inspect (or to have their plumber inspect) the service line where it entered the home and report back on the form provided, within 90 days of receipt, whether the service line was lead, copper, galvanized steel or another material. The Utility provided a brochure to the owner with step-by-step instructions on how to identify the service line material. (A copy of the identification procedure can be viewed at www.madisonwater.org/leadstep.html.) The results of this survey became the Utility's initial record of location of customer-owned lead service lines.

In order to ensure the accuracy of the information submitted through the customer self-inspection survey, the Utility took several steps. First, it created a profile of likely locations of customer lead service lines, including age of home and utility service material type, and compared the results of the survey with the profile. If the survey data did not meet the profile, the Utility scheduled an inspection to verify the service type. Second, the Utility trained its meter inspectors to identify service line materials and instructed them to report the service line material type each time they conducted their routine meter change-outs. This information is compared to survey results and changes to the record are made where needed. Since the meter change-out cycle at the Utility is about 10 years, a final verification of all survey results will take that long to complete, but the Utility is assured of eventually having a reliable record of where all customer-owned lead service lines are located.

The Utility started its complete lead service line replacement program on the basis of the survey results and any additional information it receives on an ongoing basis through profile-comparison verifications and meter inspector reports. By the end of the ten-year replacement program, all properties will have undergone a meter change-out and associated utility verification of service type. Consequently, by the end of the replacement program, the Utility will be reasonably assured that all customer lead service lines have been identified and replaced.

Appendix D. Sample Letters to Customers

EXAMPLE A – Initial Notification

Date

Homeowner Address

Subject: Replacement of Lead Service Line

Dear [Homeowner],

Our records show that you are served through a lead water service line. The (name of utility) recommends that you retain a licensed plumber to replace your lead service line at a time that coincides with replacement of the utility-owned segment of the service by (name of utility). (Name of Utility) tentatively projects scheduled replacements on your block to begin in 6 to 12 months.

You will receive another notice as the start of the lead replacement project nears, notifying you more specifically of the projected schedule. The purpose of this letter is to inform you of the upcoming project and of the recommendation that you replace your lead water service at that time, enabling you to better plan for the cost of replacement.

(Name of Water Utility) will replace the portion of any lead water service line in the street right-of-way at no cost to you. Property owners are responsible for paying to replace the portion of any lead water service line on their property between the street and the water meter. The average cost for replacement of the property owner's portion of a lead water service line has been approximately $(insert amount). The actual cost may vary, however, depending on site-specific conditions. Property owners are urged to obtain bids from two or more plumbers in order to obtain the best possible price. Some plumbers may be willing to provide a discount if they are able to mobilize for a number of replacement projects in the same neighborhood at the same time.

We hope that this information will help you plan for the upcoming lead service replacement project. If you have any questions please feel free to contact us at the numbers or email addresses provided above.

Sincerely,

[Signature Authority for Utility]

EXAMPLE B – Notification When Utility Work is About to Begin

Date

Homeowner Address

Subject: Replacement of Lead Service Line

Dear [Homeowner],

(Name of utility) will be replacing the portion of your lead water service in the street right-of-way in the next 30 to 90 days. This letter is provided to notify you of the recommendation that you replace the portion of the lead service line located on your property at the same time the Water Utility replaces the service line in the street right-of-way.

We suggest that you obtain bids for the work from several licensed plumbers and then choose the plumber that gives you the best bid. The plumber will schedule and coordinate the work with the Water Utility.

The Water Utility work in the street right-of-way will take approximately one day to complete. A temporary patch in the road will be placed soon after the excavation. The final restoration work in the terrace and the reconstruction of the street will be completed at a later date as scheduling permits. Tree trimming, pruning or removal may be required.

After the lead pipes have been replaced, we recommend that you continue to run cold water to flush the plumbing system for several minutes each time you draw water for drinking or cooking. This may be necessary for at least three years after the lead pipes are replaced, because lead particles can remain in the system after pipe replacement.

An outline of procedures that property owners and residents can expect is enclosed. Contact telephone numbers are also included if you have any further questions or concerns.

Sincerely,

[Signature Authority for Utility]

Attachment (1): [Utility] Lead Service Line Replacement Procedures

Appendix E. Sources of Information

There is a significant body of information on the topic of dealing with lead in the drinking water supply of schools and day-care facilities. Following is a partial listing of useful reference materials and the website address at which the materials can be accessed

American Water Works Association
http://www.awwa.org

American Water Works Association Research Foundation
http://www.awwarf.org/research/TopicsAndProjects/Resources/SpecialReports/Corrosion/index.aspx

Centers for Disease Control:
CDC Childhood Lead Poisoning Prevention Program
http://www.cdc.gov/nceh/lead/about/program.htm

CDC Childhood Lead Poisoning Surveillance
http://www.cdc.gov/nceh/lead/surv/surv.htm

National Rural Water Association
http://www.nrwa.org/

U.S. Environmental Protection Agency
http://www.epa.gov/safewater/lead/index.html

Implementation of the Lead and Copper Rule - http://www.epa.gov/safewater/lcrmr/implement.html

Plumbing Standards
http://www.nsf.org

Hotlines:

National Lead Information Center: 800-424-LEAD

EPA Safe Drinking Water Hotline: 800-426-4791

Phosphate Reduction Agenda Reponses

What would be the process, via NR 809/CFR 141.80 for the Dept. to allow a system to remove lead service lines, and reduce phosphate addition?

The first option is an EPA-issued variance under Sec. 1415(a) of the SDWA. This authority has already been used by EPA for LCR treatment technique variances and is quite broad, allowing EPA and DNR considerable flexibility in constructing the variance conditions.

SEC. 1415. (a) Notwithstanding any other provision of this part, variances from national primary drinking water regulations may be granted as follows:

***

(3) The Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis of the variance.

A second possible option, which has not previously been used and is less definitive, might be to construct an argument for using the DNR equivalent of 141.82(h) and the definition of optimal corrosion control in the LCR. The basis for the modification would be that all LSLs have been removed so the same level of treatment is no longer needed and it may in fact result in increased DBP precursor levels in the waters used by the PWS, potentially causing the PWS to violate another national primary drinking water regulation.

(h) *Modification of State treatment decisions.*
Upon its own initiative or in response to a request by a water system or other interested party, a State may modify its determination of the optimal corrosion control treatment under paragraph (d) of this section or optimal water quality control parameters under paragraph (f) of this section. A request for modification by a system or other interested party shall be in writing, explain why the modification is appropriate, and provide supporting documentation. The State may modify its determination where it concludes that such change is necessary to ensure that the system continues to optimize corrosion control treatment. A revised determination shall be made in writing, set forth the new treatment requirements, explain the basis for the State's decision, and provide an implementation schedule for completing the treatment modifications.

Optimal corrosion control treatment, for the purpose of subpart I of this part only, means the corrosion control treatment that minimizes the lead and copper concentrations at users' taps while insuring that the treatment does not cause the water system to violate any national primary drinking water regulations.

Must all LSL be removed?
Partial LSL replacement?

Unless all portions of LSL are removed, lead levels at homes with partial LSLs will likely increase following partial LSL replacement, and will definitely increase when PO4 is reduced. As with Madison, this is likely to be the most challenging issue we have to deal with, but there may be workable options to deal with these situations:

- EPA/DNR/PWS fact sheets/mailers/public meetings on advantages of LSL removal vs increased PO4 addition;
- City ordinances requiring the removal of all portions of the LSLs;
- Financial assistance to pay for removal of the privately-owned portion on the basis that all taxpayers benefit from replacing LSLs by way of eliminating the permanent cost of operating/maintaining OCCT;
- PWS allowance for homeowners to pay for the LSL removal over time via water bill.

See the following AWWA document (attached) for ideas on variance condition/construct ideas: *Strategies to Obtain Customer Acceptance of Complete Lead Service Line Replacement*

Definition of Tier 1 sample locations

Not sure what this is asking.

What type of information must a system provide if they want to undertake such a project?

The elements of a SDWA variance would stipulate eligibility requirements, and to participate, a PWS must satisfy these eligibility requirements. DNR could stipulate that the PWSs sign an enforceable agreement with initial information required and reporting requirements as well.

What interim/compliance monitoring would be required?

Under an alternative treatment technique, compliance monitoring could remain the same as now, with additional activities potentially being:

- annual diagnostic monitoring;
- inventory of LSLs (see process used by Madison);
- project information to homeowners with LSLs;
- post LSL removal flushing instructions; and
- periodic aerator cleaning instructions for residents

USEPA Regulatory Update

Lead and Copper Rule Revisions

Miguel A. Del Toral
U.S. EPA Region 5

1

Overview

- History of LCR Revisions
- Updates on Science
  - Lead Health Effects
  - Sampling Site Selection
  - Sampling Protocol
  - Treatment
- Summary

2

Lead and Copper Rule Rulemaking History

History of LCR Revisions

- Original Lead and Copper Rule was promulgated in 1991
  - Many studies have been conducted since 1991 on LCR-related topics, including corrosion and corrosion control
  - Lessons learned from systems attempting to simultaneously comply with multiple NPDWRs
- Several revisions have been made to the rule since 1991
  - LCR Minor Revisions in 2000
  - LCR Short-term Revisions in 2007
- Significant issues left for LCR 'Long-term' revisions

LCR Long-Term Revisions (LCR-LTR)

- Potential Changes to Lead and Copper Rule
  - Sample site selection criteria (lead and copper)
  - Sampling procedures for lead and copper tap monitoring
  - Public education for lead and copper
  - Corrosion control treatment & process control
  - Lead service line replacement requirements
  - Remove/revise outdated requirements
  - Streamline rule requirements for systems
  - Other Issues

5

NDWAC Consultation

- National Drinking Water Advisory Council (NDWAC) Meetings
  - Optimal Corrosion Control Treatment (March 25-26. 2014)
  - Sample Site Selection (May 29-30, 2014)
  - Sampling Protocol (Sept 18-19, 2014)
  - Lead Service Line Replacement (Nov 12-13, 2014)

6

Updates on Science

Health Effects

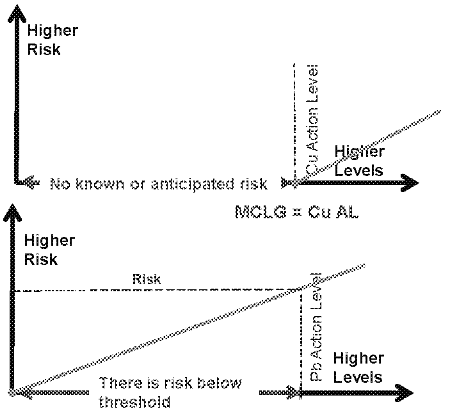
7

What is the Pb 'Action Level'?

- The Pb action level is NOT health-based
  - It's not a threshold level that separates safe and unsafe Pb levels
  - EPA and CDC Risk Assessments:
    - There is no safe level of exposure to lead.
    - Infants, children and pregnant women should avoid all exposure to lead.
  - EPA's lead action level is a threshold value which requires public water systems to *take action* to reduce consumers lead exposure if lead levels exceed the lead 'action level' of 15 ppb.
    - Set at 15ug/L in 1991 based on EPA's understanding of the existing treatment capabilities and treatment costs at that time (i.e., achievable level)

8

Explaining The Risk



When MCLG = specified value (not zero) = no known or anticipated adverse health effects occur below that value.

The Pb action level is above the health-based MCLG of zero, and so there is a risk from lead exposure below EPA's Pb action level.

MCLG for Pb = 0: No level without known or anticipated adverse health effects; Pb AL = 15 μg/L.

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Centers for Disease Control and Prevention (CDC) – on lead in DC water

"Controlling for age of housing, LSL was an independent risk factor for BLLs ≥10 mg/dL, and ≥5 mg/dL even during time periods when water levels met the US Environmental Protection Agency (EPA) action level of 15 parts per billion (ppb)."

- Childhood lead poisoning prevention programs should be made aware of the results of local public water system lead monitoring measurement under LCR and consider drinking water as a potential cause of increased BLLs, especially when other sources of lead exposure are not identified.
- When investigating cases of children with BLLs at or above the reference value established as the 97.5 percentile of the distribution of BLLs in U.S. children aged 1–5 years, drinking water should be considered as a source.

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Low Lead Level Exposure Harms Children: A Renewed Call for Primary Prevention (January 4, 2012)

Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) ***of the Centers for Disease Control and Prevention***

- Reaffirmed there is no safe level of lead exposure.
- Recommended eliminating term 'blood lead level of concern' – replaced with 'reference value' (currently 5ug/dL) to emphasize that there is no safe level.
- Reaffirmed the best way to protect children is to prevent lead exposure in the first place.

"In January 2012, a committee of experts recommended that the CDC change its "blood lead level of concern." The recommendation was based on a growing number of scientific studies that show that even low blood lead levels can cause lifelong health effects."

http://www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf

11

Fetal Death and Reduced Birth Rates Associated with Exposure to Lead-Contaminated Drinking Water

- Fetal death rates (FDR) in Washington DC (1997-2004) peaked in 2001 when water lead levels (WLLs) were highest.
- FDR were minimized in 2004 after public health interventions were implemented to protect pregnant women.
- Birth rates in DC increased versus Baltimore City and versus the United States in 2004-2006, when consumers were protected from high WLLs.
- After public health protections were removed in 2006, DC FDR spiked in 2007-2009 versus 2004-2006 in a manner consistent with high WLL arising from partial lead service line replacements.

http://pubs.acs.org/doi/full/10.1021/es4034952

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Fetal Death and Reduced Birth Rates Associated with Exposure to Lead-Contaminated Drinking Water

- DC FDR dropped to historically low levels in 2010-2011 after consumers were protected and the PSLR program was terminated.
- Re-evaluation of construction-related miscarriage cluster in the USA Today Building (1987-1988), demonstrates that high WLLs from disturbed plumbing were a possible cause. Overall results are consistent with prior research linking increased lead exposure to higher incidence of miscarriages and fetal death, even at blood lead elevations (≈ 5 ug/dL) once considered relatively low.

http://pubs.acs.org/doi/full/10.1021/es4034952

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Lead & Element Percentages in Corrosion Byproduct Solids

Lead & Element Percentages in Important Corrosion Byproduct Solids

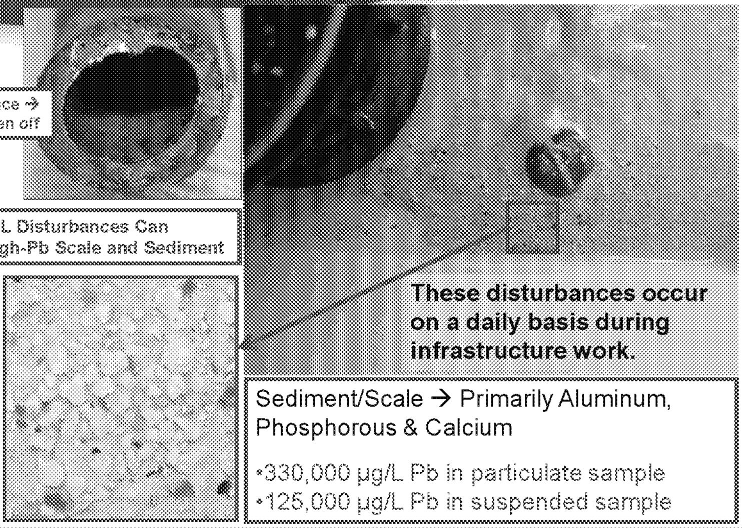
Mineral Name	Formula	% Pb	%C	%O	%S	% P	%Cl
litharge, massicot	PbO	**97.80**	0.00	7.20	0.00	0.00	
plattnerite, scrutinyite	PbO_2	**86.60**	0.00	13.40	0.00	0.00	
Cerussite	$PbCO_3$	**77.50**	4.50	18.00	0.00	0.00	
Hydrocerussite	$Pb_3(CO_3)_2(OH)_2$	**80.10**	3.10	16.50	0.00	0.00	0.00
Plumbonacrite	$Pb_{10}(CO_3)_6(OH)_6O$	**81.30**	2.80	15.70	0.00	0.00	0.00
Anglesite	$PbSO_4$	**68.30**	0.00	21.10	10.60	0.00	0.00
Leadhillite, Susannite, MacPhersonite	$Pb_4(SO_4)(CO_3)_2(OH)_2$	**76.80**	2.20	17.80	3.00	0.00	0.00
Hydroxypyromorphite	$Pb_5(PO_4)_3OH$	**77.43**	0.00	15.55	0.00	6.95	0.00
Chloropyromorphite	$Pb_5(PO_4)_3Cl$	**76.38**	0.00	14.15	0.00	6.85	2.61
Tertiary Lead Orthophosphate	$Pb_3(PO_4)_2$	**76.60**	0.00	15.80	0.00	7.60	0.00
Lead(II) orthophosphate	$Pb_9(PO_4)_6$	**76.60**	0.00	15.80	0.00	7.60	0.00

The federal definition of lead-based paint is 0.5 percent lead (0.5%).

14

Lead Service Line Disturbances
Partial LSL Replacement

LSL disturbance → Scale has fallen off



Physical LSL Disturbances Can Dislodge High-Pb Scale and Sediment

These disturbances occur on a daily basis during infrastructure work.

Sediment/Scale → Primarily Aluminum, Phosphorous & Calcium

- 330,000 μg/L Pb in particulate sample
- 125,000 μg/L Pb in suspended sample

Lead service line disturbances were found to be a common factor for the majority of sites with high lead levels. It is also possible that low water usage may play a role in sites with the highest lead levels.

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Public Education / Risk Communication

- Residents with LSLs should be alerted to the risks posed by LSLs
- PWSs should not assure residents that the water is safe to drink when it is not
  - Not an accurate statement
  - Residents will not take measures to protect their families
- Notify residents of risks from particulate lead and scale/sediment release from LSL disturbances
- Thoroughly flush the lines following LSL disturbances and provide flushing and aerator cleaning instructions to residents when LSLs are disturbed

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Sampling Site Selection

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Sources of Lead in Drinking Water

- Lead service lines
  - Largest single source of lead in distribution system where present
  - Millions installed in many systems throughout U.S. going back over 100 years ago
  - Very durable: 100+ yr old LSLs are still in service and have not degraded.
- **Leaded brass (brass meters, faucets, valves, connectors, couples, etc.)**
  - Commonly found in most homes
  - Lead content and leaching potential varies significantly
  - Devices meeting 0.25% on wetted surface began to emerge with CA and VT legislation before 2011 SDWA Amendments.
  - Significance will decline over time as existing devices are replaced with 2014-compliant devices, but can still be a factor in the near term
- **Leaded solder**
  - Common in homes built prior to SDWA use prohibition in 1986
  - Significance continues to diminish with time

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Lead Release Mechanisms
Water Quality Factors

- **Corrosive/Aggressive Water Quality**
  - Corrosive/Aggressive water can dissolve lead into the water and cause release of lead particles
- **Water Chemistry**
  - Iron and Manganese can sorb lead and transport it into home plumbing ('seeds' home plumbing with lead)
  - Natural Organic Matter (NOM) in source water can increase lead release
  - Chloride-to-Sulfate Mass Ratio can increase galvanic corrosion.
  - Chemistry of water varies and can change over time
    - Can affect the composition and stability of scales within LSLs and lead release

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Lead Release Mechanisms
Physical and Chemical Disturbances

- **Physical and chemical disturbances of LSL scales can cause lead to dissolve into water and/or particulate lead release into the water**
  - Water chemistry changes can result in high lead release system-wide*
  - Physical disturbances to LSLs can release lead-bearing scale and sediment at individual sites*
- **Galvanic Corrosion**
  - Connection of copper pipe to lead pipe during partial LSL replacement can cause galvanic corrosion of lead
    - Chloride to sulfate mass ratio can impact severity of galvanic corrosion.

*where lead sources are present

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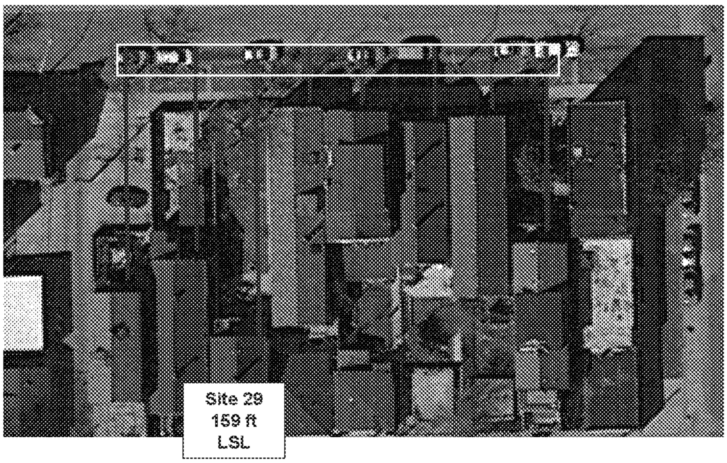
Lead Release: Other Factors

- **Variable Length of LSLs**
  - Can vary significantly within same system
  - Longer LSLs can contribute more lead
- **Current rule allows 50% LSL sites and 50% leaded-solder sites as Tier 1 sites**
  - Sites with LSLs yield much higher results overall than non-LSL sites
- **Water Usage Varies from Site to Site**
  - Low water use homes may perpetually have high lead
  - Homes become vacant and are subsequently re-occupied
  - Stagnation can affect protective scales within LSLs
- **Particulate Lead is released sporadically**
  - Can increase with higher flow rates

21

Distance Between Water Main and Homes Varies Significantly



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Major Variability Factors: Summary Table

Example of Realistic Site Characteristics within the Same Public Water System

Higher Risk/Lead Release Factors

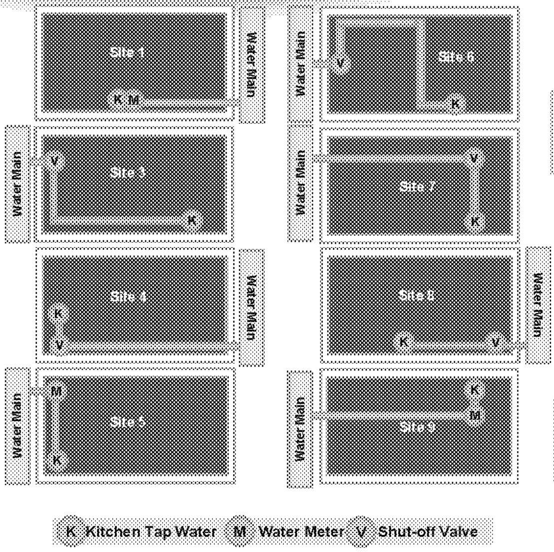
Site	Recently re-occupied	Lower water use	Disturbed LSL	Partial LSL	Longer LSL	Warmer water temps	Fe/Mn in water	Aggressive water zone
1	X	X		X		X	X	
2		X	X		X		X	
3			X		X			X
4	X			X		X		X
5		X			X		X	X
…								

Lower Risk/Lead Release Factors

Site	Continuously occupied	Higher water use	Undisturbed LSL	No LSL	No partial LSL	Shorter LSL	Colder water temps	No Fe/Mn in water	Non-aggressive water zone
6	X			X	X			X	
7	X		X		X	X	X	X	X
8	X	X		X			X	X	
9	X		X		X	X		X	X
10	X	X		X	X		X	X	
…									

Sampling Protocol

Distance Between Kitchen Taps and LSLs Varies Considerably

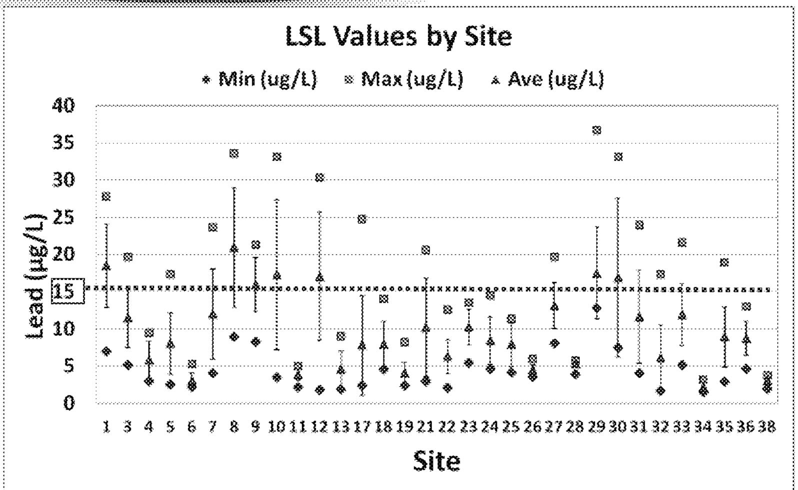


Plumbing configurations within each home varied significantly.

Some LSLs end just inside the front wall; Some continue beyond.

25

Pb is Variable Across Sites



A PWS can meet or not meet the lead AL based on the sites that are selected for compliance sampling.

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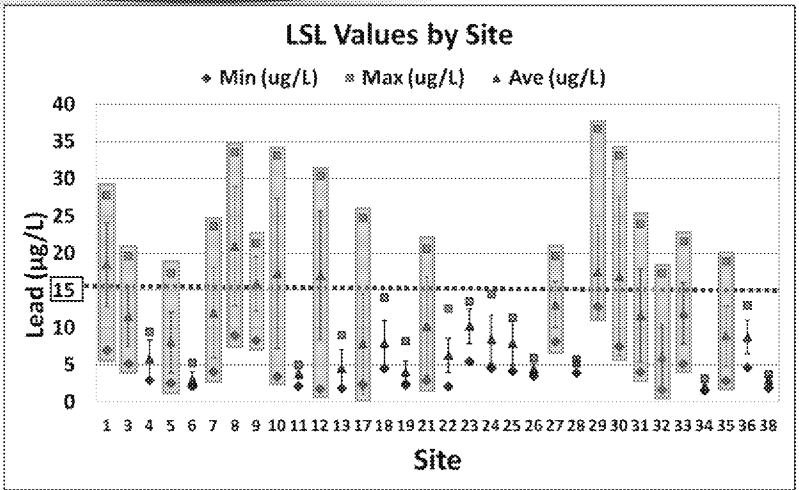
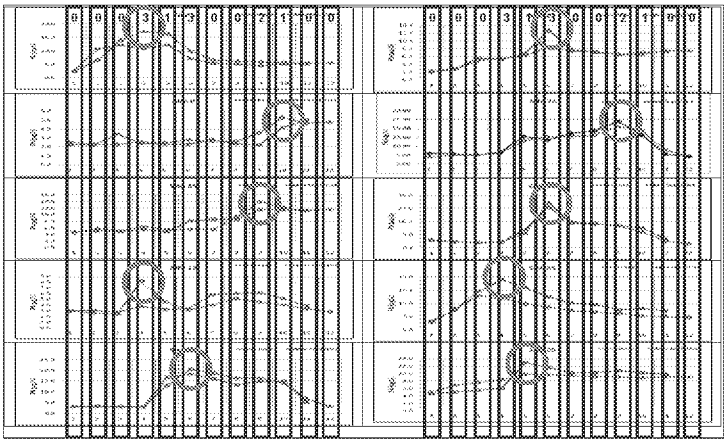
Pb is Variable Within Each Site



Even if the worst-case sites are chosen, a PWS can meet or exceed the lead action level based on the liter selected for the LSL sample (53% of sites in this study).

27

Peak Pb Occurs at Different Points



High lead levels in water can easily be missed

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Using Same Liter at all Sites Misses Peak at Most/All Sites

June (28 Sites)												
If this liter is used across all sites	1st liter	2nd liter	3rd liter	4th liter	5th liter	6th liter	7th liter	8th liter	9th liter	10th liter	11th liter	12th liter
No. of sites that miss peak lead value	28	27	26	25	26	22	25	28	24	24	28	26
Percent of sites that miss peak lead value	100 %	96%	93%	89%	93%	79%	89%	100 %	86%	86%	100 %	93%

September / October (30 Sites)											
If this liter is used across all sites	1st liter	2nd liter	3rd liter	4th liter	5th liter	6th liter	7th liter	8th liter	9th liter	10th liter	11th liter
No. of sites that miss peak lead value	30	29	28	27	28	25	24	30	23	28	28
Percent of sites that miss peak lead value	100%	97%	93%	90%	93%	83%	80%	100%	77%	93%	93%

High lead levels in water can easily be missed

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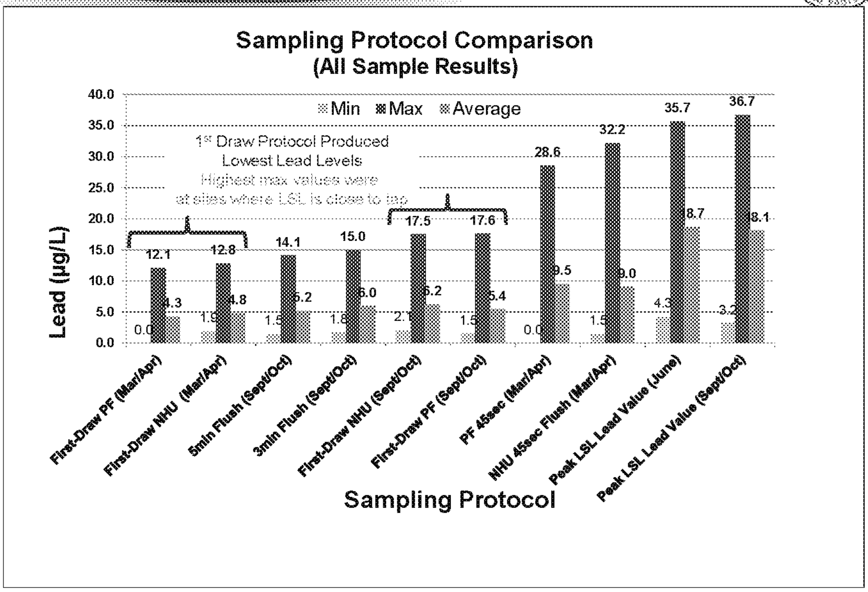
Comparison of Sampling Protocol Results



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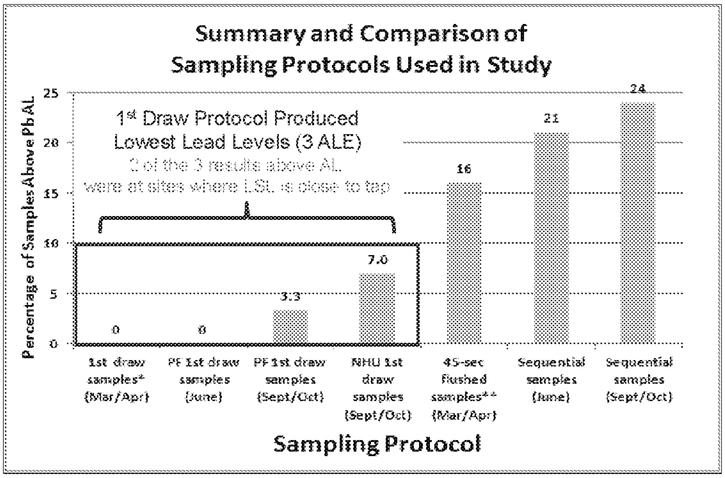
Results Above Pb Action Level



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LSL Contributes to Each Liter of Water Passing Through

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Treatment

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Optimal Water Quality Parameters Are Not Controlling Pb/Cu Levels

- A PWS is in compliance with requirement to minimize Pb/Cu levels if they meet the OWQPs designated by the State.
- Since original LCR was promulgated:
  - Over 6,000 lead action level exceedances for CWSs in SDWIS/FED
  - Many more copper action level exceedances at CWSs and many more lead and copper action level exceedances at NTNCWSs
  - Most systems are in compliance with OWQPs.
    - Only 172 OWQP violations over same timeframe indicates that LCR's OWQP compliance framework is not effectively controlling lead levels.

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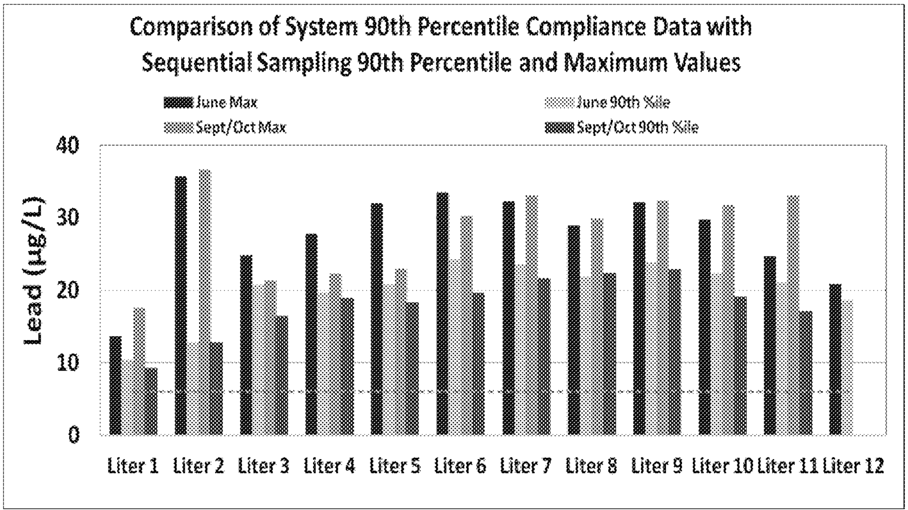
Comparison of 90th Percentiles



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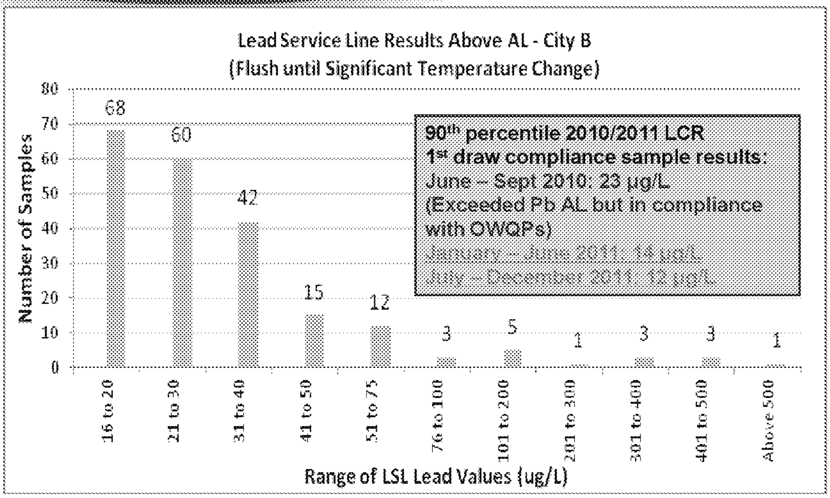
Comparing 1st Draw to LSL Samples Using LCR Sample Protocols



2011 LSL Sampling Results (1,975 Sites Sampled)
213 results (11%) above the lead AL, ranging from 16 µg/L to 580 µg/L
85 results (4.3%) above twice the AL

- 90th Percentile using all 1,975 LSL sample results: 16 µg/L
- No LSLs were required to be replaced (7 percent of LSLs tested under AL)

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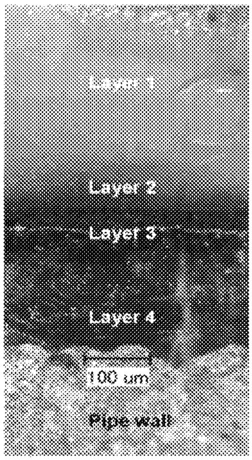
Lead Service Line Scales

Lead Service Line (LSL) Scales
The composition, stability and solubility of LSL scales can and do vary considerably. It's important to know what is happening inside the LSLs: Unstable scales can result in high particulate release. Studies can inform, and common scientific principles can be used for treatment, but all systems are different, so CCT may not be working according to theory or as anticipated in a given system.



Magnified Scales View: Separated into layers by color and texture.

Photo: USEPA-ORD

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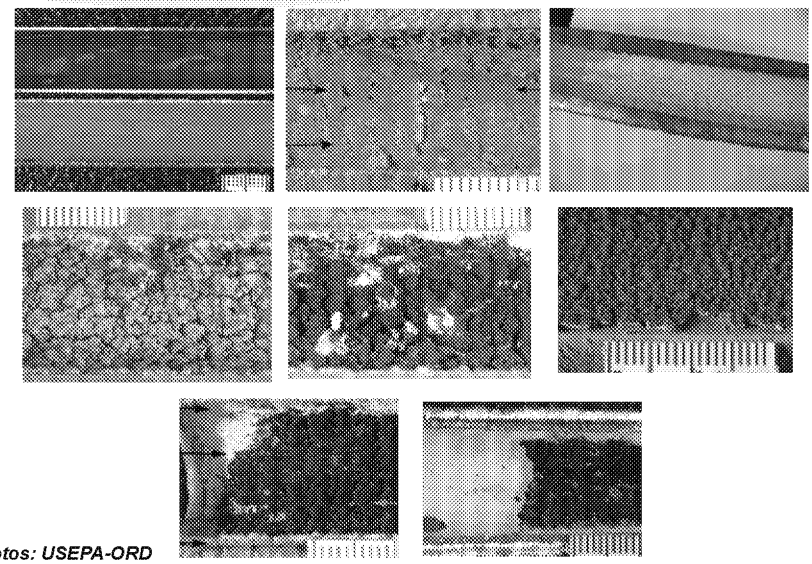
Lead Service Line Scales



Photos: USEPA-ORD

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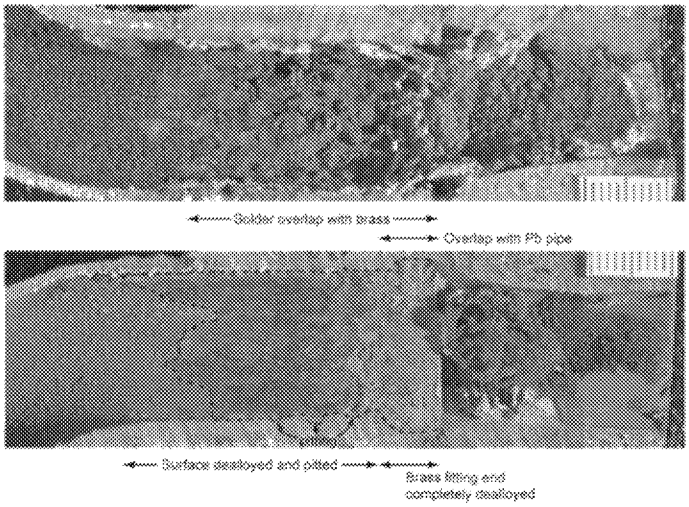
USEPA-ORD Study on Galvanic Corrosion Evidence



Connections between lead pipe and brass or copper in *some* water systems show boundaries where scale mineral transitions reflect pH conditions much lower than bulk water, consistent with expected impacts of CSMR or other factors increasing galvanic corrosion

Photos: USEPA-ORD

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Summary

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Is the Water Safe to Drink?

- Based on the health effects studies as well as data and studies in systems with LSLs, the answer is very likely 'no' for most homes with LSLs.
- **Physical LSL disturbances happen daily**
  - Water main repair/replacement; meter and shut-off valve repair, installation & replacement
  - Number of Partial LSLR from infrastructure work far exceeds LCR-required LSLR
- **Maintaining optimal treatment is important, but does not address all risk factors**
  - Homes with low water use; LSL Disturbances; Galvanic corrosion from partial LSLR; Re-occupied homes that were unoccupied for extended periods of time.

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Is the Water Safe to Drink?

- **Water quality changes**
  - Can affect Pb levels system-wide or in specific areas
  - Water main material/condition can affect pH/Pb levels in some areas
- Scale/sediment released from LSL disturbances can be dangerous and should be flushed thoroughly out of home plumbing.
- Residents should be reminded that aerators should be cleaned regularly
- **Water usage varies and can change**
  - Varies from site to site and usage at any site can go from high to low, low to high, stay high or stay low.
  - Homes become vacant and are subsequently re-occupied

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Additional Information

For more information on Chicago Lead Sampling Study:
http://www.epa.gov/Region5/water/chicagoserviceline/index.html

- Chicago Lead in Drinking Water Study (download)
- Advice for Residents
- How do I know if I have a LSL
- What do LSLs look like
- Cleaning aerators
- Flushing instructions
- Collecting water samples

Questions on LSL scales and analyses:

Michael R. Schock
(513) 569-7412
schock.michael@epa.gov

Related Journal Article:
Del Toral, M. A., Porter, A., & Schock, M. R. (2013). Detection and Evaluation of Lead Release from Service Lines: A Field Study. *Environmental Science and Technology, 47(16),* 9300-9307. doi:10.1021/es4003636

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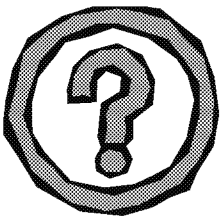

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**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
(U.S. EPA) REGION 5**

IN THE MATTER OF:	
Alternative Treatment Technique for	)
Reduction of Lead in Drinking Water for	) **VARIANCE UNDER SECTION UNDER**
Certain Public Water Systems in	) **SECTION 1415(A)(3) OF SDWA**
Wisconsin ~~Communities~~	)

INTRODUCTION

A. Statutory and Regulatory Background

Under the Safe Drinking Water Act (SDWA), 42 U.S.C. §§300f-300j-26, U.S. EPA promulgates national primary drinking water regulations (NPDWRs), which specify for certain drinking water contaminants either a maximum level or treatment technique with which public water systems (PWSs), including community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) must comply. U.S. EPA has promulgated an NPDWR for lead and copper, the Lead and Copper Rule (LCR), 40 C.F.R. Part 141, Subpart I, that includes a treatment technique which consists of multiple components, requiring CWSs and ~~non-transient non-community water systems (~~NTNCWS~~)~~ to take various steps to ensure that users of their system are not exposed to levels of lead and/or copper in drinking water that would result in adverse health effects. ~~Although the LCR applies to both NTNCWSs and CWSs, these system types have many significant differences and this variance focuses on CWSs and the unique challenges posed by the LCR to CWSs.~~ The LCR requires all CWSs and NTNCWSs to optimize corrosion control and to conduct tap water monitoring to ensure that lead and copper levels are minimized at users' taps. If tap water levels exceed either 'action level' (AL) of 0.015 mg/L for lead or 1.3 mg/L for copper, in more than 10 percent of drinking water tap samples (i.e., exceeds the AL as a 90th percentile value), CWSs and NTNCWSs are required to take additional steps, including delivering public education materials to users explaining the health risks from lead in drinking water (for lead AL exceedances), treating source water if it contains elevated lead and/or copper levels, or installing optimal corrosion control treatment (OCCT) for CWSs that were considered to have optimized corrosion control without having installed treatment. For systems that continue to exceed the lead AL after installing OCCT, the system must begin replacing at least seven percent of lead service lines (LSLs) in the system per year. LSLs that contribute less than 0.015 mg/L of lead do not need to be replaced and can be counted toward the number of LSLs required to be replaced.

The Wisconsin Department of Natural Resources (WDNR) has primary enforcement responsibility for administering the LCR because it has adopted regulations that are at least as stringent as the federal regulations (see Wisconsin Administrative Code NR 809 Subchapter II). The State regulation currently applies to all CWSs and NTNCWSs in Wisconsin. The U.S. EPA has the authority to grant a variance from any treatment technique upon a showing by any person that the alternative treatment technique is at least as efficient in lowering the level of that contaminant in drinking water. Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), provides:

> *"The Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."*

See also 40 C.F.R. §142.46.

B. Factual Background

The LCR requires that all CWSs and NTNCWSs optimize corrosion control to minimize lead and copper levels at consumers' taps. Many CWSs and NTNCWSs (referred to hereafter as PWSs) currently utilize orthophosphate as the primary lead and copper corrosion control mechanism. The addition of orthophosphate has been effective at reducing lead and copper levels in drinking water under the SDWA. However, recent studies on ~~CWSs with~~ LSLs indicate that the current sampling protocol in the LCR can significantly underestimate lead levels and many ~~CWSs~~ PWSs have lead levels that are much higher than previously believed. Studies conducted on the adverse health effects from lead since the original LCR was promulgated continue to reaffirm that there is no safe level of lead exposure and that even low lead levels cause harm. Consequently, the current level of treatment may be insufficient to protect public health in many CWSs, and it may be necessary for ~~CWSs~~PWSs with LSLs to significantly increase the level of orthophosphate needed to reduce lead levels in the drinking water. The available options for effectively reducing lead and copper levels in ~~CWSs~~PWSs with LSLs without the use of orthophosphate are very limited, potentially requiring significant capital improvements as well as other water quality and operational changes due to the public health risk posed by the LSLs and the life expectancy of the LSLs.

The allowable discharge limits for phosphorus into receiving waters are being lowered under the Clean Water Act (CWA) in Wisconsin such that the amount of orthophosphate that may be needed to effectively reduce lead levels in drinking water as part of the OCCT for SDWA compliance would require certain entities under the CWA to install treatment to remove the phosphorus prior to being able to discharge into receiving waters even where they have added none of the phosphorus themselves (e.g., entities using potable water in non-contact cooling water applications that is discharged to receiving waters). Many of the same entities regulated under both the CWA and SDWA must comply with lead in drinking water reductions under the SDWA and phosphorus discharge limits under the CWA. To satisfy the regulatory requirements under both statutes, a community with LSLs may be required to increase the level of orthophosphate at the drinking water plant in order to protect public health from lead in drinking water under the SDWA, which will increase the level of phosphorus in the waste water, while also working to achieve compliance with reduced phosphorus discharge limits into receiving waters under the CWA.

Almost all lead and copper comes from plumbing materials transporting drinking water to the homes via the distribution system and from plumbing within the homes themselves, therefore there is no possibility to remove these contaminants at the drinking water treatment plant. A SDWA ban on the use of leaded solder and other leaded plumbing materials became effective in 1986 with subsequent additions and modifications to the law since then. It is no longer permissible to install new leaded materials in potable water applications within a ~~CWS~~PWS or premise plumbing. While the SDWA prohibits the introduction of most leaded materials into the plumbing network, it does not require the removal of existing lead sources. LSLs, leaded brass and to a more limited extent leaded solder continue to leach lead into the drinking water, with the largest individual source being LSLs where they are present. LSLs can contribute up to 75 percent of the total lead mass in the drinking water and the lead that is released from LSLs can also accumulate in premise plumbing. It is estimated that there are approximately 10 million full or partial ~~lead service lines~~LSLs currently in service ~~in CWSs~~. Many extracted LSLs that had been in use for over 100 years show no signs of degradation and it is expected that existing LSLs still in service can easily last another 100 years without appreciable degradation if they are allowed to remain in service.

Where LSL replacement is required under the current LCR, a ~~CWS~~PWS that is triggered into LSL replacement is currently only required to remove the portions of the LSLs that they own. This process is called a partial lead service line replacement, which recent studies have shown can increase lead levels by disturbing or dislodging the protective scales within the LSLs. In addition, infrastructure maintenance activities, such as water main replacements, cause physical disturbances to LSLs which can result in the release of scale and sediment particles containing high lead concentrations from within LSLs. Lead-bearing particles are also released sporadically from within LSLs on a daily basis in many public water systems due to galvanic corrosion as a result of partial LSL replacement and the subsequent re-connection of the remaining portion of the lead pipe to new copper pipe. These lead-bearing particles often contain a very high percentage of lead by weight (68 to 98 percent), far exceeding the 0.5 percent lead content defined by U.S. EPA for lead paint. The number of LSLs that are physically disturbed or partially removed during routine infrastructure work far exceeds the number of LSLs disturbed when LSLs are partially replaced under the LCR requirements and there are currently no requirements in the LCR associated with LSLs that are disturbed or partially replaced in the course of routine infrastructure work.

There are many significant differences between NTNCWSs and CWSs which necessitate the use of different approaches for these system types. NTNCWSs are generally much simpler systems and do not have most of the complex issues associated with CWSs. Among the differences, the percentage of homes with LSLs in a CWS can vary from a small number to most or all homes served by the CWS. A typical NTNCWS is usually a single structure with one LSL or a limited number of structures with at most a small number of LSLs. A CWS may also have portions of the LSLs that are publicly owned and portions that are privately owned, whereas most NTNCWSs own the entire water distribution system. As a consequence of these and other differences, most CWSs have more significant challenges than NTNCWSs in complying with the LCR, and many issues that are relevant to CWSs are not relevant to NTNCWSs.

In most typical communities, only a portion of the community has LSLs, but orthophosphate is applied centrally at one or more treatment plants to all of the water distributed throughout the community. Given the findings of the recent studies on lead levels and health effects, the continued presence of the LSLs in the community and the life expectancy of the LSLs that are currently in service may necessitate an increase in the amount of orthophosphate used at the treatment plant(s) on a permanent basis. This requires a community with LSLs to pay for a higher level of drinking water treatment than would be necessary if the community did not have LSLs, and the corresponding increase in phosphorus levels in the waste water can exacerbate efforts by communities to improve local water quality conditions. Degradation of water bodies in Wisconsin that are used as drinking water sources could in turn require public water systems and other entities that utilize those sources to install new treatment or modify their existing treatment and operations as a result of the degraded water quality.

In addressing the risk posed by LSLs, it is essential that communities develop strategies to manage infrastructure in a sustainable manner, such that the overall long-term costs to communities is minimized.

> *"Drinking water and wastewater systems should use robust and comprehensive planning processes to pursue water infrastructure investments that are cost-effective over their life cycle, are resource efficient, and are consistent with community sustainability goals."*
> *(EPA's Clean Water and Drinking Water Infrastructure Sustainability Policy)*

The U.S. EPA and the WDNR have agreed on the need to better integrate implementation of the statutory and regulatory requirements under the Clean Water Act (CWA) and SDWA to protect public health and improve our nation's environment and the U.S. EPA is committed to protecting source waters from contamination that can adversely affect drinking water sources.

> *"I have directed my staff to continue CWA/SDWA integration actions that have been a priority for the past two years. The operating principle of these policy efforts is that, while public water systems are legally accountable for the delivery of safe drinking water to their consumers, no water system should have to provide more treatment than that which is necessary to address naturally occurring pollutant concentrations e.g., minerals leaching from rock formations, wildlife contamination unrelated to anthropogenic activities."*
> – G. Tracy Mehan III, Assistant Administrator for Water

The U.S. EPA and WDNR also agree that solutions to public health and environmental problems must also incorporate the principles outlined in Presidential Order 12898 on Environmental Justice.

"To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands."
-Executive Order 12898 (February 11, 1994)

"Every American deserves clean air, water and land in the places where they live, work, play and learn. Through our implementation of Plan EJ 2014, the EPA will be leading by example in expanding the conversation on environmentalism and working for environmental justice – now and into the future."
-Lisa Jackson, U.S. EPA Administrator

EPA is also committed to the principles outlined in the President's Memorandum on Transparency and Open Government:

"Government should be transparent. Transparency promotes accountability and provides information for citizens about what their Government is doing. Information maintained by the Federal Government is a national asset. My Administration will take appropriate action, consistent with law and policy, to disclose information rapidly in forms that the public can readily find and use. Executive departments and agencies should harness new technologies to put information about their operations and decisions online and readily available to the public. Executive departments and agencies should also solicit public feedback to identify information of greatest use to the public.

"Government should be participatory. Public engagement enhances the Government's effectiveness and improves the quality of its decisions. Knowledge is widely dispersed in society, and public officials benefit from having access to that dispersed knowledge. Executive departments and agencies should offer Americans increased opportunities to participate in policymaking and to provide their Government with the benefits of their collective expertise and information. Executive departments and agencies should also solicit public input on how we can increase and improve opportunities for public participation in Government.

"Government should be collaborative. Collaboration actively engages Americans in the work of their Government. Executive departments and agencies should use innovative tools, methods, and systems to cooperate among themselves, across all levels of Government, and with nonprofit organizations, businesses, and individuals in the private sector. Executive departments and agencies should solicit public feedback to assess and improve their level of collaboration and to identify new opportunities for cooperation."
(Memorandum for the Heads of Executive Departments and Agencies-

January 21, 2009)

WDNR Proposal

Rather than continuing to maintain and potentially increase the amount of orthophosphate currently being used and needed to mitigate lead levels at consumers' taps, the WDNR proposes to focus on removing all LSLs in ~~CWSs~~PWSs, along with a corresponding re-evaluation of existing State OCCT designations, with the intent of modifying the State-designated OCCT to eliminate or reduce the level of orthophosphate addition to the water supply where it is safe to do so. The WDNR proposes that this approach be allowed for certain CWSs and NTNCWSs in Wisconsin that meet specific criteria. The WDNR believes this alternative approach will be at least as efficient as the current LCR treatment technique in lowering lead and copper levels in drinking water.

This approach would also provide CWSs with the ability to better plan and coordinate LSL replacement with other planned infrastructure improvements, like water main replacement or sewer work, which can result in cost efficiencies and significant cost savings for CWSs. This is consistent with U.S. EPA's sustainability policy, as it provides a more comprehensive and sustainable approach to public health protection and environmental protection~~.~~. Facilitating the removal of the entire length of all LSLs, including the resident-owned portions of the LSLs, would benefit all residents in the community by allowing the reduction or elimination of the use of orthophosphate and the associated costs to operate and maintain the treatment, which could provide a significant permanent cost savings to all residents of the CWS under both the SDWA and CWA. Elimination of the LSLs can also significantly reduce the complexity of compliance with other SDWA regulations.

Based on the recent health effects and LSL studies reaffirming the harm from lead and highlighting that lead levels in LSLs can be significantly higher than previously known, interim measures will also be needed to protect pregnant women and children in homes that have LSLs. Training and educational material specific to the potential risks posed by LSLs in the community as well as the potential risks from LSLs and LSL disturbances are also needed to better inform those that provide care for the most vulnerable residents as well as the local childhood lead poisoning prevention programs for investigating water as a potential exposure source for children with elevated blood lead levels (EBLLs).

Once a PWS has removed all LSLs in the system, a system may submit a request to the WDNR to study modifications to the State-designated corrosion control, with the intent of reducing or eliminating the addition of orthophosphate-based corrosion inhibitors where it is safe to do so.

The use of additional interim protective measures ~~also~~ may also allows some communities to begin evaluating the potential for reducing orthophosphate levels once these additional interim measures are in place, rather than waiting until all LSLs have been removed. This provision would only be allowed at the discretion of the WDNR where it is deemed feasible and where a PWS has made a commitment to dedicate the resources necessary to manage the provision of water filters and replacement cartridges to all homes with LSLs. This provision should only be considered in cases where it is possible to conclusively identify all homes with LSLs in the system, such that there is not a risk that homes with LSLs may have been missed during the LSL inventory effort.

If a PWS makes a commitment to dedicate resources to implement a program to manage the provision of water filters and replacement cartridges to all residents in homes with LSLs, as well as an ongoing public education on the health risks from LSLs and the importance of continuous use of the filters, the removal of all LSLs would not be necessary prior to considering any reduction in orthophosphate.~~Removal of all LSLs would not be necessary prior to considering any reduction in orthophosphate as residents in homes with LSLs will be provided water filters and aggressive public education on LSLs and the importance of using the filters.~~

Decisions on how to structure and plan the LSL removal program are to be made within each community in consultation with the WDNR ~~by the~~ and local authorities, water systems and residents, such that cost efficiencies can be realized and decisions on environmental justice issues can be made within the affected communities. For CWSs where all LSLs have been conclusively verified, ~~O~~once all residents with LSLs have been identified and provided water filters to protect their families, a CWS can submit a request to WDNR ~~begin~~ to evaluate reducing or eliminating the use of orthophosphate for corrosion control, and the potential for using pH/alkalinity adjustment as an alternative to orthophosphate to control lead release from remaining lead sources.

Along with the interim measures, conforming changes to the monitoring structure are necessary since the LCR would require CWSs with LSLs to collect samples at LSL sites, all of which would be using water filters. A modified monitoring program is therefore needed to assess the relative risks from the remaining lead sources in the community based on premise plumbing materials, to better inform residents as to the potential risks that are more specific to their homes (e.g., homes with copper pipes, galvanized iron pipes) and to assess the potential for reducing or eliminating the use of orthophosphate for corrosion control.

Once LSLs are fully removed from a system, the remaining sources of lead would be leaded-solder, leaded-brass and residual lead that has accumulated within premise plumbing from the LSLs. All three sources are expected to diminish over time as leaded-solder is no longer allowed to be sold or used for potable water applications, the prohibition on the sale and use of brass plumbing components became effective in January 2014, and with the removal of all LSLs, the LSLs will no longer be contributing lead to the premise plumbing. Consequently, a CWS may be able to significantly reduce or eliminate the use of orthophosphate for corrosion control, as many CWSs that do not have LSLs currently use pH/alkalinity adjustment to successfully control lead release from these sources.

The U.S. EPA, Region 5, has reviewed WDNR's proposal and believes that the proposal has merit and that the alternative treatment technique will be at least as efficient in lowering the level of lead and copper in drinking water than the specified treatment technique under the current LCR. The U.S. EPA and WDNR have concluded that changes can be made under existing law, and the U.S. EPA agrees to initiate the process for making the changes following applicable procedures. ~~U.S. EPA, Region 5, has reviewed WDNR's proposal and believes that~~

~~the proposal has merit and that the alternative treatment technique will be at least as efficient in lowering the level of lead and copper in drinking water than the specified treatment technique under the current LCR.~~

U.S. EPA has identified a variance, pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), as the appropriate legal mechanism for providing the regulatory flexibility which WDNR has requested. The variance allows certain ~~CWSs~~ PWSs to use the alternative treatment technique, where specific conditions are met, in lieu of the treatment technique established under the current LCR. The variance establishes participation criteria that a PWS~~CWS~~ must meet in order to qualify for the alternative treatment technique. The variance also sets forth the performance criteria that the ~~CWS~~PWS must meet to continue to be allowed to use this alternative treatment technique. To ensure that the alternative treatment technique is as effective as possible, and provides at least an equivalent level of protection as the existing regulations, U.S. EPA and WDNR have entered into the "Memorandum of Understanding Between Wisconsin Department of Natural Resources and U.S. Environmental Protection Agency" (hereinafter "MOU") as Attachment C~~B~~ to this variance, describing the roles and responsibilities of each agency in implementing the variance. The MOU specifies State oversight requirements which WDNR must follow to insure the proper implementation of the variance and the use of this alternative treatment technique.

C. FINDINGS OF FACTS

1. This matter comes before the Regional Administrator of U.S. EPA, Region 5, on request by WDNR, for a State-wide variance pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3).

2. Pursuant to Section 1401(4)(A)of SDWA, 42 U.S.C. §300f(4)(A), a PWS is a system that provides drinking water to the public for human consumption through pipes or other constructed conveyances, and that has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

3. A CWS is a PWS which serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents.

~~3.~~4. A NTNCWS is a PWS that is not a CWS and that regularly serves at least 25 of the same persons over 6 months per year.

~~4.~~5. Pursuant to Section 1401(1)(A) of SDWA, 42 U.S.C. §300f(1)(A), because CWSs and NTNCWSs are PWSs, ~~all~~ NPDWRs apply to CWSs and NTNCWSs.

~~5.~~6. The LCR is a NPDWR that requires all CWSs and NTNCWSs to comply with the regulatory requirements specified at 40 C.F.R. §141.80 through §141.91.

7. WDNR requests that a State-wide variance be granted, allowing CWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in Attachment A

(Community Water System Agreement) in lieu of complying with specific regulatory provisions outlined in the LCR.

~~6.~~8. WDNR requests that a State-wide variance be granted, allowing NTNCWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in Attachment B (Non-transient Non-community Water System Agreement) in lieu of complying with specific regulatory provisions outlined in the LCR.

D. CONCLUSIONS OF LAW

1. Section 1415 (a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), authorizes the U.S. EPA Administrator to grant a variance from a treatment technique of an NPDWR:

   "...upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."

2. Title 40 C.F.R. Part 142, Section 142.46 grants the U.S. EPA Administrator the authority to grant a variance from any treatment technique requirement of a national primary drinking water regulation to a supplier of water, whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility.

3. The authority to issue SDWA variances for treatment technique requirements was delegated to the Regional Administrators on June 12, 2000. Delegation 9-69, *Issuance of Variances for Treatment Technique Requirements*.

4. A CWS in Wisconsin will be eligible for this variance only upon application to and approval by WDNR, ~~for this variance only~~ if the CWS meets the eligibility criteria specified in the order (Section F.1) and complies with all requirements specified in the "Community Water System Agreement" in Attachment A (hereinafter "CWS Agreement") of this variance, and the MOU with WDNR included in Attachment ~~B~~C and referenced in Section E remains in full effect.

5. CWSs shall implement the alternative treatment technique specified in the CWS Agreement, in lieu of complying with the LCR requirements specified in 40 CFR Part 141 Subpart I, unless otherwise specified in the CWS Agreement.

6. A NTNCWS in Wisconsin will be eligible for this variance only upon application to and approval by WDNR, if the CWS meets the eligibility criteria specified in the order (Section F.1) and complies with all requirements specified in the "Non-community Water System Agreement" in Attachment B of this variance, and the MOU with WDNR included in Attachment C and referenced in Section E remains in full effect.

~~5.~~7. NTNCWSs shall implement the alternative treatment technique specified in the NTNCWS Agreement, in lieu of complying with the LCR requirements specified in 40 CFR Part 141 Subpart I, unless otherwise specified in the NTNCWS Agreement.

E. MOU Between WDNR and U.S. EPA

U.S. EPA Region 5 and WDNR have entered into the MOU in Attachment ~~B~~C (hereby incorporated by reference), which will become effective upon the signing of this variance, and which describes each agency's responsibilities and commitments regarding the variance and the alternative treatment technique. WDNR will review and act on all submittals in accordance with the MOU established herein. Approval for the use of the alternative treatment technique for any CWS will be determined on a case-by-case basis by WDNR in accordance with the provisions of this variance and the MOU between EPA and WDNR.

The U.S. EPA will review the MOU and State reporting contained therein on an annual basis, to determine if all variance conditions and the terms and conditions of the MOU continue to be met. Should revisions to the LCR be promulgated in the future, the U.S. EPA will review the variance criteria and conditions to determine whether the variance criteria and conditions require modification to continue to meet the requirements of SDWA Section 1415(a)(3).

F. ORDER

It is therefore ordered:

That in consultation with WDNR, the Regional Administrator, U.S. EPA, Region 5, finds that WDNR has made a showing for a variance under Section 1415(a)(3) of SDWA. WDNR's request for a State-wide variance is granted, subject to the following conditions:

1. All participating ~~CWSs~~PWSs shall meet all eligibility criteria outlined in this paragraph (F.1.a through F.1.x), and shall comply with all requirements specified in the CWS Agreement or NTNCWS Agreement, as applicable. The requirements specified in the CWS Agreement constitute the alternative treatment technique for CWSs and the requirements specified in the NTNCWS Agreement constitute the alternative treatment technique for NTNCWs. Both the CWS Agreement and the NTNCWS Agreement ~~and~~ are hereby incorporated by reference.

   a. The ~~CWS~~PWS must demonstrate to the satisfaction of the WDNR that the ~~CWS~~PWS retains the legal authority to remove or require the removal of all LSLs and portions of LSLs within the public water system, including all privately-owned portions of LSLs.
   b. The ~~CWS~~PWS must enter into a legally-binding CWS Agreement or NTNCWS Agreement, as applicable, with the WDNR to remove all LSLs and portions of LSLs within the distribution system, including all privately-owned portions of any LSLs,

within the timeframe specified in the CWS Agreement or NTNCWS Agreement, as applicable.

c. Not later than 90 days following the signing of ~~this~~ the CWS or NTNCWS ~~a~~Agreement, the ~~CWS~~ PWS must notify any public water systems to which they sell water of the intent to request a modification to their existing state-designated OCCT.
d. The ~~CWS~~PWS must sign a legally binding CWS Agreement or NTNCWS Agreement, as applicable, committing to implementation of all applicable requirements contained in the CWS Agreement or the NTNCWS Agreement.
e. [Additional WDNR criteria?]

2. Failure to comply with any condition, criteria or requirement in this order or in the CWS Agreement or NTNCWS Agreement, as applicable, will automatically terminate the ~~CWS~~PWS eligibility for this variance. This variance shall also terminate:

   a. Upon termination of the MOU by either WDNR or U.S. EPA; or
   b. Upon a determination by U.S. EPA or WDNR that the alternative treatment technique no longer meets the requirements for equivalent lead reduction required under the provisions of Section 1415(a)(3) of SDWA; or
   c. Upon a determination by U.S. EPA that the WDNR is not meeting the terms and conditions of the MOU.

3. In the event that the variance terminates, all ~~CWSs~~PWSs subject to this variance shall be required to comply with all applicable requirements under the LCR beginning no later than [xx days] from the date of notification of the termination of the variance.

4. The Regional Administrator shall retain jurisdiction and shall annually review the circumstances pertaining to the variance, and may modify or revoke the variance for any PWS~~CWS~~ or for all ~~CWSs~~PWSs if any provisions or conditions of the variance are not met.

5. Notwithstanding any other provision contained in this variance, the U.S. EPA may require any ~~CWS~~PWS to take such actions as deemed necessary to ensure that public health is protected.

6. Nothing in this Order alters or otherwise affects any requirement applicable under the State law.

Dated:

Susan Hedman, Regional Administrator
U.S. EPA, Region 5

RARE Project Title: ***Improving control technologies governing release of lead into drinking water under the Safe Drinking Water Act (SDWA) to limit impacts on phosphorus discharges under the Clean Water Act (CWA)***

Regional Technical Contacts:
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Regional Manager's Name and Signature:
Thomas Poy, Chief, Ground Water and Drinking Water Branch, (312) 886-5991

Regional Manager's Signature | Date of Signature

Regional Division Director's Name and Signature:
Tinka G. Hyde, Director, Water Division

Regional Division Director's Signature | Date of Signature

RSL's Name and Signature:
Carole Braverman, Regional Science Advisor

Carole Brav | 6/2/2014

RSL's Signature | Date of Signature

ORD Project Officers:

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6/1/2014

ORD Manager's Signature | Date of Signature

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Thomas Poy 5/30/14

Regional Manager's Signature Date of Signature

Regional Division Director's Name and Signature:
Tinka G. Hyde, Director, Water Division

5/30/14

Regional Division Director's Signature Date of Signature

RSL's Name and Signature:
Carole Braverman, Regional Science Advisor

RSL's Signature Date of Signature

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ORD Manager's Name and Signature:
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ORD Manager's Signature Date of Signature

See other signature page

REGIONAL SCIENCE NEED:

Many regions in the US have tens of thousands to millions of lead pipes, primarily in the form of service lines, conveying drinking water. These pipes are particularly prevalent in older, large and medium-sized industrial cities, such as are common in Region 5. Lead is a highly toxic material with a Maximum Contaminant Level Goal of zero for drinking water. Under the Lead and Copper Rule (LCR), the water utility is responsible for optimizing corrosion control for lead release through central water treatment. For the vast majority of drinking water systems that do not have low alkalinity, the most effective way to reduce lead exposure is to add 0.5 to 2 mg P/L of orthophosphate to the water. The effectiveness of this measure depends on background water chemistry (such as pH, alkalinity and the presence or absence of other deposits on the pipe surfaces). In Region 5, many water systems employ blended phosphate chemicals as corrosion inhibitors, which are proprietary mixtures of orthophosphate with unidentified polyphosphate chemical species. And at the same time, there are growing concerns to minimize the input of more phosphorous to the natural water environment via wastewater treatment discharges under the CWA.

At this time EPA is revising the (LCR), and a critical issue is knowledge of the effectiveness of various treatment alternatives to minimize lead release into the water. While thermodynamic predictions can suggest low lead release levels, the ability of phosphate-containing chemicals and pH/alkalinity adjustment to achieve low levels of lead release from the worst-case condition of water in direct contact with the lead pipes is poorly known. Few studies have looked at profiles of lead levels throughout premise plumbing using sequential sampling when lead service lines (LSLs) are present, but of those, virtually none have examined either phosphate-treated water systems or lead levels in the higher hardness and alkalinity waters common to the Midwest. Additionally, this project facilitates implementation of EPA's commitment to partner with states through stakeholder collaboration in the reduction of nutrients in our nation's waters.

Based on recent studies indicating that lead levels in drinking water for PWSs with LSLs can be significantly higher than current compliance monitoring indicates, minimizing lead release under the LCR may necessitate increasing the amount of orthophosphate added to the drinking water which directly or indirectly is then discharged into the receiving waters in Wisconsin, even as the State of Wisconsin is working to reduce allowable phosphorus discharges under the CWA. EPA Region 5 is in the process of working with the state of Wisconsin on a state-wide SDWA variance that would establish an alternative treatment technique for controlling lead release into the drinking water designed to eliminate or mitigate potential increases in the use of orthophosphate by PWSs in Wisconsin.

In conjunction with, and in support of the development of an alternative treatment technique, this project is designed to acquire practical and useful data for the first time, on relationships of lead release from LSLs to address a) the degree of effectiveness of different levels of phosphate treatment of different types in different background water chemistries, b) determine the relative success of pH/alkalinity adjustment compared to phosphate treatment. This information will directly aid in the determination of the necessity and cost/effectiveness of different dosages of orthophosphate for drinking water treatment, assessment of the potential benefit of LSL removal relative to treatment, and the probability of meeting the Lead Action Level with either pH/alkalinity adjustment or phosphate treatment.

SPECIFIC GOALS AND APPROACH:

The primary objective of this effort is to provide technical support for controlling lead release into the drinking water for public water systems (PWSs) in Region 5, to minimize the likelihood of adverse impacts on phosphorus discharges under the CWA due to potential changes in the Lead and Copper Rule, and to support the development of a state-wide alternative treatment technique under Section 1415(A)(3) of the SDWA for reducing or eliminating orthophosphate addition by PWSs for controlling lead release. This research includes bench and pilot scale studies in NRMRL laboratories designed to better understand the mechanisms that cause lead release into the drinking water and the corresponding treatment for controlling lead release.

There are three highly important objectives for this research. (1) Identify at least 10 water systems in Region 5 that have LSLs and are using either orthophosphate or a blended phosphate chemical for corrosion control treatment. Depending on level of collaboration of residents and water systems, lead profiling using a sequential sampling procedure will be conducted at a minimum of 3 sites from each system. The plumbing configuration of each site from which samples are taken will be characterized, including pipe type, length, and diameter, location of inline devices, existence and location of soldered joints, in-line devices, and fittings. Installation, replacement and repair dates will be gathered for each site where possible, as well as the occurrence of any repairs or causes of disturbances of interior or exterior plumbing lines.

Treatment histories will be gathered for each system in which LSL profile sequential sampling is done. Historical background water quality information will be collected, and NRMRL laboratory will perform complete major constituent background chemical characterization of the water (with appropriate shipping and preservation precautions), including an ICAP/OES metals scan. The Region 5 laboratory will analyze specific key metals of interest (Pb, Zn, Cu, Fe, Mn, Ni) relating to LCR concerns with digestion, as needed.

If water systems or residents are replacing all or parts of LSLs, segments of lines from representative sites from each system where they are available will be shipped to AMSARC/NRMRL in Cincinnati for optical, chemical and mineralogical analyses of solid phases in the pipe scales. This information will be related to lead levels observed in the profiling, and will be used for refining predictive modeling of lead release mechanisms and performance of lead release control mechanisms.

EXPECTED RESULTS AND PRODUCTS:

The results of this study will be used in the development of technical guidance and support for PWSs in optimizing treatment for controlling lead release from LSLs, and the development of options for controlling lead release under an alternative treatment technique. The results will be communicated in the form of presentations, Journal manuscripts, and a final project report. Through direct collaboration with Region 5, Region 5 States and utility operators in Region 5, the project has the potential for real-time outcomes and methodologies that can be used throughout the Midwest to assist PWSs with simultaneous compliance under the SDWA and CWA.

TRANSLATION, IMPLEMENTATION, COMMUNICATION PLAN:

Communicating the results and products to PWSs with LSLs, engineering firms, and state officials that need the information most is essential. ORD communication staff will be made available to develop outreach materials. Examples of outreach materials include website postings, mass mailed visually descriptive tri-fold brochures, and a webinar. Lastly, the ORD lead will present the findings to a location in Region 5.

PROPOSED BUDGET:

Water analysis laboratory support student or SEE	$40,000
Laboratory supplies, sample shipping	$20,000
Contractor laboratory support or MS-level student trainee for corrosion scale characterization	$40,000
TOTAL	**$100,000**

PROJECT TIMELINE: 2015 - 2016

Spring 2015: Ground water systems
Summer 2015: Surface water systems
Fall 2015 – Summer 2016: Data analysis and LSL pipe scale analyses

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
(U.S. EPA) REGION 5

IN THE MATTER OF:

Alternative Lead in Drinking Water Reduction Treatment Technique for Wisconsin Public Water Systems	)) **VARIANCE UNDER SECTION UNDER**) **SECTION 1415(A)(3) OF SDWA**)

INTRODUCTION

A. Statutory and Regulatory Background

Under the Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26 (SDWA), U.S. EPA promulgates national primary drinking water regulations (NPDWRs), which specify for certain drinking water contaminants either a maximum level or treatment technique with which community water systems (CWSs) must comply. U.S. EPA has promulgated an NPDWR for lead and copper, the Lead and Copper Rule (LCR), 40 C.F.R. Part 141, Subpart I, that consists of a treatment technique requiring CWSs to take various steps to ensure that users of their system are not exposed to levels of lead and/or copper in drinking water that would result in adverse health effects. The LCR requires all CWSs to optimize corrosion control and to conduct tap water monitoring to ensure that lead and copper levels are minimized at users' taps. If tap water levels exceed either 'action level' (AL) of 0.015 mg/L for lead or 1.3 mg/L for copper, in more than 10 percent of drinking water tap samples (i.e., exceeds the AL as a 90^{th} percentile value), CWSs are required to take additional steps, including delivering public education materials to users about the health risks of lead in drinking water (for lead AL exceedances), treating source water if it contains elevated lead and/or copper levels, or installing optimal corrosion control treatment (OCCT). For systems that continue to exceed the lead AL after installing OCCT, the system must begin replacing at least seven percent of lead service lines (LSLs) in the system per year. LSLs that contribute less than 0.015 mg/L of lead do not need to be replaced and can be counted toward the number of LSLs required to be replaced.

The State of Wisconsin has primary enforcement responsibility for administering the LCR because it has adopted regulations that are at least as stringent as the federal regulations. See Wisconsin Administrative Code [add citation(s)]. The State regulation currently applies to all CWSs in Wisconsin.

U.S. EPA has the authority to grant a variance from any treatment technique upon a showing by any person that the alternative treatment technique is at least as efficient in lowering the level of that contaminant in drinking water. Section 1415(a)(3) of SDWA, 42 U.S.C. § 300g-4(a)(3), provides:

> *"The Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."*

See also 40 C.F.R. §142.46.

B. Factual Background

LSLs are by far the largest source of lead in drinking water distribution systems and can contribute up to 75 percent of the total lead mass released into the drinking water (cite/reference in supporting documents). It is estimated that there are approximately [xx million] service lines that are partially or fully made of solid lead. Many extracted LSLs that had been in use for over 100 years show no signs of degradation and it is expected that existing LSLs still in service can easily last another 100 years without appreciable degradation if they are allowed to remain in service. Infrastructure maintenance activities, such as water main replacements cause physical disturbances to LSLs which can result in the release of scale and sediment particles from within LSLs, and lead-bearing particles are also released sporadically from within LSLs on a daily basis in many public water systems due to galvanic corrosion and other factors. The lead-bearing particles released into the drinking water can contain over 90 percent lead by weight (cite/reference in supporting documents), far exceeding the lead content defined by U.S. EPA for lead paint (cite/reference in supporting documents). U.S. EPA and the Wisconsin Department of Natural Resources (WDNR) have agreed on the need to better integrate implementation of the statutory and regulatory requirements under the Clean Water Act (CWA) and SDWA to protect public health and improve our nation's environment.

Therefore, the U.S. EPA and WDNR have agreed to establish a more effective treatment technique approach to reducing the lead levels in drinking water which would be more protective of public health than the treatment technique under the current LCR, would potentially reduce the phosphorus loadings in Wisconsin waters and promote a more cost-effective and sustainable solution for CWSs with LSLs. The U.S. EPA and WDNR have concluded that successful projects demonstrate that in some cases, changes in U.S. EPA regulations, policies, guidance, or interpretations are needed to improve upon the nation's existing public health and environmental protection system. Where such changes can be made under existing law, U.S. EPA agrees to initiate the process for making the changes following applicable procedures.

The LCR requires that all CWSs optimize corrosion control to minimize lead and copper levels at consumers' taps. Many CWSs currently utilize orthophosphate as the primary lead and copper corrosion control mechanism and the addition of orthophosphate has been effective at reducing lead and copper levels in drinking water under the SDWA. The allowable discharge limits for phosphorus into receiving waters are being lowered under the CWA in Wisconsin such that the amount of orthophosphate being added as part of the OCCT for SDWA compliance would require certain entities under the CWA to install treatment to remove the phosphorus prior to being able to discharge into receiving waters even where they have added none of the phosphorus themselves (e.g., entities using potable water in non-contact cooling water applications that is discharged to receiving waters). Almost all lead and copper comes from plumbing materials transporting drinking water to the homes via the distribution system and from plumbing within the homes themselves, therefore there is no possibility to remove these contaminants at the drinking water treatment plant.

A SDWA ban on the use of leaded solder and other leaded materials became effective in 1986 with subsequent additions and modifications to the law since then. It is no longer permissible to install most leaded materials in potable water applications within a CWS or premise plumbing. While the SDWA prohibits the introduction of most leaded materials into the plumbing network, it does not require the removal of existing lead sources. LSLs, leaded brass and to a more limited extent leaded solder continue to leach lead into the drinking water, with the largest contributor overall being LSLs. Recent studies on CWSs with LSLs indicate that lead levels can be much higher than previously believed and it may be necessary in order to protect public health for CWSs to significantly increase the level of orthophosphate needed to reduce lead levels in the drinking water. The available options for effectively reducing lead and copper levels in CWSs with LSLs without the use of orthophosphate are very limited and could require significant additional water quality and operational changes, including capital improvements.

Many of the same entities regulated under both the CWA and SDWA must comply with lead in drinking water reductions under the SDWA and phosphorus discharge limits under the CWA. To satisfy the regulatory requirements under both statutes, a CWS with LSLs may be required to increase the level of orthophosphate at the drinking water plant in order to protect public health from lead in drinking water and to also install treatment to remove the same orthophosphate they have added to the drinking water prior to being able to discharge into receiving waters under the CWA.

The WDNR has proposed an alternative treatment technique for compliance with the LCR, which the WDNR believes will be more efficient than the current LCR treatment technique in lowering lead and copper levels. WDNR proposes that this alternative treatment technique be allowed for certain CWSs in Wisconsin that meet specific criteria. The alternative treatment technique specified in this variance contains provisions to lower the levels of lead in the drinking water, along with a corresponding re-evaluation of existing State OCCT designations, with the intent of modifying the State-designated OCCT to eliminate or reduce the level of orthophosphate addition to the water supply where it is safe to do so. This alternative treatment technique will also provide CWSs with the ability to better plan and coordinate LSL replacement with infrastructure work which can result in cost efficiencies and significant cost savings for CWSs.

U.S. EPA, Region 5, has reviewed WDNR's proposal and believes that the proposal has merit and that the alternative treatment technique will be more efficient in lowering the level of lead and copper in drinking water than the specified treatment technique under the LCR and will realize public health benefits more quickly than proposed revisions to the LCR, which optimistically would begin to realize public health benefits from LSL replacement in 2028 or beyond.

U.S. EPA has identified a variance, pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. § 300g-4(a)(3), as the appropriate legal mechanism for providing the regulatory flexibility which WDNR has requested. The variance allows certain CWSs to use the alternative treatment technique where specific conditions are met, in lieu of the treatment technique established under the current LCR. The variance establishes participation criteria that a CWS must meet in order to qualify for the alternative treatment technique. The variance also sets forth the performance criteria that the CWS must meet to continue to be allowed to use this alternative treatment technique. To ensure that the alternative treatment technique is as effective as possible, and provides at least an equivalent level of protection as the existing regulations, U.S. EPA and WDNR have entered into a Memorandum of Understanding (MOU) describing the roles and responsibilities of each agency in implementing the variance. The MOU specifies State oversight requirements which WDNR must follow to insure the proper implementation of the variance and the use of this alternative treatment technique.

C. FINDINGS OF FACTS

1. This matter comes before the Regional Administrator of U.S. EPA, Region 5, on request by WDNR, for a State-wide variance pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. § 300g-4(a)(3).

2. Pursuant to Section 1401(4)(A)of SDWA, 42 U.S.C. § 300f(4)(A), a PWS is a system that provides drinking water to the public for human consumption through pipes or other constructed conveyances, and that has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

3. A CWS is a PWS which serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents.

4. Pursuant to Section 1401(1)(A) of SDWA, 42 U.S.C. § 300f(1)(A), because CWSs and are PWSs, certain NPDWRs apply to CWSs.

5. The LCR requires all CWSs to comply with the regulatory requirements specified at 40 C.F.R. § 141.80 through § 141.91.

6. WDNR requests that a State-wide variance be granted, allowing CWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in this variance in lieu of complying with specific regulatory provisions outlined in the LCR.

D. CONCLUSIONS OF LAW

1. Section 1415 (a)(3) of SDWA, 42 U.S.C. § 300g-4(a)(3), and 40 C.F.R § 142.46, authorize the Administrator to grant a variance from a treatment technique of an NPDWR:

   "...upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."

2. The authority to issue SDWA variances for treatment technique requirements was delegated to the Regional Administrators on June 12, 2000. Delegation 9-69, *Issuance of Variances for Treatment Technique Requirements*.

3. A CWS in Wisconsin will be eligible upon application to and approval by WDNR, for this variance only if the CWS meets the following eligibility criteria listed in paragraph D.4 and also complies with all of the requirements in paragraph D.5, and the U.S. EPA determines that the WDNR is satisfactorily implementing the terms and conditions of the MOU referenced in paragraphs D.8 and D.9. The eligibility criteria specified in paragraph D.4., together with the requirements specified in paragraph D.5. constitute the alternative treatment technique.

4. CWS Eligibility Criteria – In order to be considered eligible by the WDNR for this variance, a CWS must meet the following criteria:

   [CWS eligibility criteria – See attached discussion document]

5. In addition to meeting the eligibility criteria in paragraph D.4., a CWS must also comply with all of the following requirements in this paragraph (D.5.) to continue to be eligible for this variance.

   [REQUIREMENTS TBD – See attached discussion document]

6. The conditions specified in paragraph D.4. and the requirements specified in paragraph D.5. above will be incorporated into individual agreements between WDNR and each participating CWS as required in paragraph D.4., including any additional requirements specified by WDNR.

7. CWSs meeting the criteria and conditions in paragraphs D.4. and D.5. shall implement the alternative treatment specified in paragraphs D.4. and D.5., as documented in the agreement required in paragraph D.4., in lieu of complying with the requirements specified in [scope to be determined: §§ 141.80 through 141.82, 141.84, 141.86, 141.87 and 141.88.]:

8. U.S. EPA and WDNR have entered into an MOU (hereby incorporated by reference), which will become effective upon the finalization of this variance, and which describes

each agency's responsibilities regarding the variance and the alternative treatment technique. WDNR will review and act on all submittals in accordance with the MOU established herein.

9. Approval for the use of the alternative treatment technique for any CWS will be determined on a case-by-case basis by WDNR in accordance with the provisions of this variance and the MOU between EPA and WDNR.

10. The U.S. EPA will review the MOU and State reporting contained therein on an annual basis, to determine if all variance conditions and the terms and conditions of the MOU continue to be met

11. Following the promulgation of final revisions to the LCR, the U.S. EPA will review the variance criteria and conditions to determine whether the variance criteria and conditions require modification to continue to meet the requirements of SDWA Section 1415(a)(3).

E. ORDER

It is therefore ordered:

That in consultation with WDNR, the Regional Administrator, U.S. EPA, Region 5, finds that WDNR has made a showing for a variance under Section 1415(a)(3) of SDWA. WDNR's request for a State-wide variance is granted, subject to the following conditions:

1. All participating CWSs shall meet the eligibility criteria outlined in paragraph D.4. of this variance, and shall comply with the requirements specified in paragraph D.5. of this variance.

2. Failure to comply with any requirement in paragraphs D.4. or D.5. will automatically terminate the CWS eligibility for this variance. This variance shall also terminate:

   a) Upon termination of the MOU by either WDNR or U.S. EPA; or
   b) Upon a determination by U.S. EPA or WDNR that the alternative treatment technique no longer meets the requirements for equivalent lead reduction required under the provisions of Section 1415(a)(3) of SDWA.
   c) Upon a determination by U.S. EPA that the WDNR is not meeting the terms and conditions of the MOU.

5. In the event that the variance terminates, all CWSs subject to this variance shall be required to comply with all applicable requirements under the LCR beginning no later than [xx days] from the date of notification of the termination of the variance.

6. The Regional Administrator shall retain jurisdiction and shall annually review the circumstances pertaining to the variance, and may modify or revoke the variance for any CWS or for all CWSs if any provisions or conditions of the variance are not met.

7. Notwithstanding any other provision contained in this variance, the U.S. EPA may require any CWS to take such actions as deemed necessary to ensure that public health is protected.
8. Nothing in this Order alters or otherwise affects any requirement applicable under the State law.

Dated:

Susan Hedman
Regional Administrator

U.S. EPA Region 5 / WDNR SDWA 1415(a)(3) Variance
LCR Alternative Treatment Technique

Variance Provisions – Ideas to Facilitate Discussion

The alternative treatment technique specified in this variance provides for the most cost-effective permanent solution for eliminating the largest source of lead in drinking water and integrates the requirements of the SDWA and CWA to reduce phosphorus loadings to surface waters

Alternative Treatment Technique – Major Benefits

Public health: Permanently eliminates largest source of lead in PWSs; More immediate public health protection as compared to current LCR and potential LCR revisions (LSLR would not begin until at least 2028 under LCR LTR); reduces/eliminates PWS contribution of phosphorus to surface waters

Sustainability and CWA/SDWA Integration: Significant cost reduction for LSLR as compared to triggered LSLR under the existing LCR TT; Significant long-term savings on PO4 chemical; Estimated permanent reduction of xxx pounds of phosphorus discharges and loadings to surface waters; Potentially eliminates need for pre-treatment of potable water should additional PO4 be required under potential LCR LTR requirements; Elimination of SDWA simultaneous compliance complications; Resolves conflict between water conservation and managing lead levels in drinking water; Permanent reduction in complexity of LCR LTR implementation (LSL site selection, LSL sampling, re-optimization of treatment, and triggered LSLR)

Variance Eligibility

1. The PWS has signed a legally-binding agreement (attachment to variance) with the WDNR to remove all LSLs within the distribution system, including all privately-owned portions of any LSLs receiving water from the system, within no more than [XX years] from the date of such agreement, unless a lesser amount of time is specified by the WDNR.
2. Any PWS which has agreed to participate in this variance must, no later than xx days following the signing of the PWS agreement, notify all purchasing systems of their intent to modify their current corrosion control treatment.
3. All participating PWSs must demonstrate to the satisfaction of U.S. EPA and the WDNR that they have the legal authority to require the removal of all LSLs, including all privately-owned portions of LSLs.
4. Each PWS must sign a legally binding agreement to implement all applicable requirements contained in the variance.
5. [Additional criteria?]

Variance Conditions

1. **Schedule and timeline**
   a. TBD on case by case basis (not to exceed xx years?). [Since filters are provided to all LSL homes, the timeline should allow for integration into other public works projects (significant cost reduction for LSLR)]
2. **LSL Inventory**
   a. Report all known or suspected partial and full LSLs
   b. Develop procedures for verifying LSL inventory [should take into account that some LSLs may have been illegally installed after local ban on LSLs]
   c. Develop prioritization for LSL inventory [priorities should include schools, childcare facilities, EBLL areas, (other?)]
   d. Complete an inventory of all partial or full lead service lines within the public water system, whether they are owned by the PWS or not, within [specify deadline].
3. **Communication Strategy**
   a. Strategy for ongoing communication with residents and health care providers on risks from LSLs and importance of interim mitigation efforts [should include notices to all residents so they can check if they have a LSL]
   b. Coordination with health care providers, Childhood lead poisoning prevention programs and other organizations for distribution of LSLR program fact sheets to pregnant women, patients, parents of children with EBLLs, medical community (clinics, nursing consortium, etc)
   c. Notification to State and local building/plumbing regulators of materials restrictions and LSLR program
   d. Special notice in CCR regarding the LSLR program, including monitoring results and how they differ from the current LCR
4. **Monitoring Requirements [TBD]**
   a. Continue to use 1st draw samples to monitor existing CCT effectiveness for non-LSL homes?
   b. Eliminate 1st draw compliance sampling and use resident-requested sampling? [If so, what are results used for? Determining compliance? Treatment diagnosis? Determining whether corrective actions are needed?]
   c. Other?
5. **Interim mitigation efforts**
   a. Prioritize interim mitigation measures (incorporate EJ considerations. For example, prioritize distribution of filters to schools/childcare facilities, low-income/EBLL areas).
   b. Distribute brochures or post links on website to LSLR program & buying 2014 lead-free components (see EPA ORD Brochure) for residents.
   c. Special notices to low flow and unoccupied/reoccupied homes?
   d. Replace LSLs before homes that have been unoccupied for long period are reoccupied?
   e. Flushing and periodic aerator cleaning reminders for residents whose homes had LSLs replaced since some homes will have residual 'seeded' lead in premise plumbing [for how long after LSL has been replaced? Should aerator cleaning reminders be an ongoing, permanent activity for all homes?]

f. [Additional requirements?]

6. **Removal of LSLs**
   a. A full inventory need not be complete to begin LSLR.
   b. All full and partial LSLs within PWS must be removed from the water main to the foundation of the home or internal connection (e.g., meter).
   c. LSLRs to be replaced in same priority order as LSL inventory priorities? [within reason, allowing for combining infrastructure work?]
7. **Plumbing Material Restrictions?**
   a. Agreement from CWSs not to re-install leaded-brass components such as water meters
   b. Restriction on use of copper plumbing in areas with water aggressive to copper [if the PWS wants to back off on phosphate or unconditionally? This may not be possible, since it is not under the purview of WDNR – how can this be enforced by WDNR? How can WDNR ensure that PWSs meet this criteria in the MOU?]
8. **Treatment Maintenance**
   a. Assessment of water quality aggressiveness to copper?
   b. Continue to operate within existing State-designated OWQPs?
   c. Replace OWQPs with EPA/WDNR designated operating conditions?
   d. Eliminate OWQPs and use 1st draw or resident-requested samples to trigger corrective actions?
   e. Maintain EPA/WDNR specified CSMR for controlling brass/solder?
   f. Something else?
9. **Reduction of PO4 (Process)**
   a. Contingent on non-aggressive water toward copper?
   b. Evaluation of pH/Alkalinity adjustment as an alternative to PO4 once all LSLs are removed?
   c. Monitoring of lead levels during PO4 reduction
      i. Same as now (i.e., mandatory # of sites)?
      ii. Free customer-requested samples (with minimum specified)?
      iii. Other?
   d. EPA/WDNR approval required prior to PO4 reduction
   e. Corrective actions if lead levels begin to increase [criteria TBD]
10. **PWS Reporting and Recordkeeping Requirements** [Many 141.90 and 141.91 elements are not applicable since we are not using LCR TT]
    a. Monitoring
    b. State/EPA/Public notification of high lead results
    c. Annual progress reports
    d. Mandatory notification of proposed treatment changes
    e. Annual water quality report
    f. Outreach programs
    g. Interim mitigation efforts
    h. Annual certification of compliance with variance conditions
    i. Final certification that all partial and full LSLs have been removed

U.S. EPA Region 5 / WDNR SDWA 1415(a)(3) Variance
LCR Alternative Treatment Technique

Variance Development Process

- Develop initial draft of variance package
  - Draft variance;
  - EPA/WDNR Memorandum of Understanding (MOU);
  - PWS agreement;
  - Supporting documents (how does alternative treatment technique meet variance criteria);
  - Press release & desk statement;
  - Fact sheet;
  - List of stakeholders[1]; and
  - Federal Register notice.
- Distribute draft package for internal review/clearance (Regional Offices, OEJ, OGWDW, OECA, and OGC)
- Following internal clearance, discuss draft package with WDNR including the State legal mechanism for allowing the variance. [Discuss list of potential PWS candidates]
- Incorporate any necessary revisions to variance package based on comments received.
- Work with State to develop timeline and logistics for public meeting(s). [Recommend R5 RA/WDD, WDNR Representative(s), Variance Team, and State/Local Officials to attend]
- Submit Federal Register (FR) notice for publication: Notice of Data Availability (NoDA) on draft variance, stakeholder meeting announcement. Also send FR notice and fact sheet to stakeholders.
- Attend public meeting(s).
- Review/respond to comments received.
- If decision is to proceed with variance, send final approval letter from R5 RA to WDNR Secretary stating that WDNR has successfully made a showing that the alternative treatment technique will be at least as efficient in lowering lead levels, and transmitting final variance and associated documents.

1 – Identification of Stakeholders

National/State Stakeholders: Children's health organizations (including CLPP); advocacy/local grass roots organizations, WI WWA; WRWA

- EPA R5: GWDWB; Children's Health; OEJ; OPA; ORA; NPDES
- EPA HQ: OGWDW; OECA; OEJ; OGC; ORD
- WDNR: Bureau of DWG; NPDES
- State/Local Officials: As needed, based on participating PWSs

Variance Construct – For Discussion/Development

<u>Variance Components</u>

- Background/Statement of Basis for Variance
- PWS Eligibility Criteria/Conditions/Agreement
- PWS requirements (e.g., LSL inventory and LSLR requirements; interim protective/mitigation measures; treatment maintenance; progress reports; communication strategy; public access to information; monitoring, reporting, recordkeeping, etc.)
- Schedule/Timeline for removing LSLs (flexible, to allow for significant cost reductions by combining infrastructure work)
- Conditions for potential PO4 reduction
- PWS Agreement[1]
- MOU between EPA R5 and WDNR[2]
- Variance modification/termination conditions (overall & for individual systems)
- Supporting Documents[3]

<u>1 – PWS Agreement</u>
Legal document signed by authorized official committing to compliance with criteria and conditions of variance.

<u>2 – MOU Components</u>

- EPA/State oversight commitments
- Public involvement/public access to Information
- State certification of enforceability of SDWA 2011 lead-free provisions in WI
- State reporting to EPA
  - Annual report on number of participating CWSs, including the number of known or estimated partial and full LSLs
  - Annual certification to U.S. EPA that all participating CWSs are meeting all variance criteria and requirements
- State recordkeeping

<u>3 – Supporting documents for alternative treatment technique</u>

The supporting documents would include research and studies demonstrating that the alternative treatment technique will provide at least equivalent lead reduction as compared to the existing LCR treatment technique. It should also include supporting documentation and information related to cost/benefits which should be calculated across the life expectancy of the LSLs.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
(U.S. EPA) REGION 5

IN THE MATTER OF:

Alternative Treatment Technique for Reduction of Lead in Drinking Water for Wisconsin Communities	)) **VARIANCE UNDER SECTION UNDER**) **SECTION 1415(A)(3) OF SDWA**)

____

INTRODUCTION

A. Statutory and Regulatory Background

Under the Safe Drinking Water Act (SDWA), 42 U.S.C. §§300f-300j-26, U.S. EPA promulgates national primary drinking water regulations (NPDWRs), which specify for certain drinking water contaminants either a maximum level or treatment technique with which community water systems (CWSs) must comply. U.S. EPA has promulgated an NPDWR for lead and copper, the Lead and Copper Rule (LCR), 40 C.F.R. Part 141, Subpart I, that includes a treatment technique requiring CWSs to take various steps to ensure that users of their system are not exposed to levels of lead and/or copper in drinking water that would result in adverse health effects. The LCR requires all CWSs to optimize corrosion control and to conduct tap water monitoring to ensure that lead and copper levels are minimized at users' taps. If tap water levels exceed either 'action level' (AL) of 0.015 mg/L for lead or 1.3 mg/L for copper, in more than 10 percent of drinking water tap samples (i.e., exceeds the AL as a 90th percentile value), CWSs are required to take additional steps, including delivering public education materials to users explaining the health risks from lead in drinking water (for lead AL exceedances), treating source water if it contains elevated lead and/or copper levels, or installing optimal corrosion control treatment (OCCT) for CWSs that were considered to have optimized corrosion control without having installed treatment. For systems that continue to exceed the lead AL after installing OCCT, the system must begin replacing at least seven percent of lead service lines (LSLs) in the system per year. LSLs that contribute less than 0.015 mg/L of lead do not need to be replaced and can be counted toward the number of LSLs required to be replaced.

The Wisconsin Department of Natural Resources (WDNR) has primary enforcement responsibility for administering the LCR because it has adopted regulations that are at least as stringent as the federal regulations. See Wisconsin Administrative Code [add citation(s)]. The State regulation currently applies to all CWSs in Wisconsin. The U.S. EPA has the authority to grant a variance from any treatment technique upon a showing by any person that the alternative treatment technique is at least as efficient in lowering the level of that contaminant in drinking water. Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), provides:

> *"The Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."*

See also 40 C.F.R. §142.46.

B. Factual Background

The LCR requires that all CWSs optimize corrosion control to minimize lead and copper levels at consumers' taps. Many CWSs currently utilize orthophosphate as the primary lead and copper corrosion control mechanism. The addition of orthophosphate has been effective at reducing lead and copper levels in drinking water under the SDWA. However, recent studies on CWSs with LSLs indicate that the current sampling protocol in the LCR can significantly underestimate lead levels [insert citation(s)] and many CWSs have lead levels that are much higher than previously believed. Studies conducted on the adverse health effects from lead since the original LCR was promulgated continue to reaffirm that there is no safe level of lead exposure and that even low lead levels cause harm [see Attachment C- Supporting Documents]. Consequently, the current level of treatment may be insufficient to protect public health in many CWSs, and it may be necessary for CWSs with LSLs to significantly increase the level of orthophosphate needed to reduce lead levels in the drinking water. The available options for effectively reducing lead and copper levels in CWSs with LSLs without the use of orthophosphate are very limited, potentially requiring significant capital improvements as well as other water quality and operational changes due to the public health risk posed by the LSLs and the life expectancy of the LSLs.

The allowable discharge limits for phosphorus into receiving waters are being lowered under the Clean Water Act (CWA) in Wisconsin such that the amount of orthophosphate that may be needed to effectively reduce lead levels in drinking water as part of the OCCT for SDWA compliance would require certain entities under the CWA to install treatment to remove the phosphorus prior to being able to discharge into receiving waters even where they have added none of the phosphorus themselves (e.g., entities using potable water in non-contact cooling water applications that is discharged to receiving waters). Many of the same entities regulated under both the CWA and SDWA must comply with lead in drinking water reductions under the SDWA and phosphorus discharge limits under the CWA. To satisfy the regulatory requirements under both statutes, a community with LSLs may be required to increase the level of orthophosphate at the drinking water plant in order to protect public health from lead in drinking water and to also install treatment to remove the same orthophosphate they have added to the drinking water prior to being able to discharge into receiving waters under the CWA.

Almost all lead and copper comes from plumbing materials transporting drinking water to the homes via the distribution system and from plumbing within the homes themselves, therefore there is no possibility to remove these contaminants at the drinking water treatment plant. A SDWA ban on the use of leaded solder and other leaded plumbing materials became effective in 1986 with subsequent additions and modifications to the law since then. It is no longer permissible to install new leaded materials in potable water applications within a CWS or premise plumbing. While the SDWA prohibits the introduction of most leaded materials into the plumbing network, it does not require the removal of existing lead sources. LSLs, leaded brass and to a more limited extent leaded solder continue to leach lead into the drinking water, with the largest individual source being LSLs where they are present. LSLs can contribute up to 75 percent of the total lead mass in the drinking water [insert citation(s)] and the lead that is released from LSLs can also accumulate in premise plumbing. It is estimated that there are approximately [xx million] full or partial lead service lines currently in service in CWSs. Many extracted LSLs that had been in use for over 100 years show no signs of degradation and it is expected that existing LSLs still in service can easily last another 100 years without appreciable degradation if they are allowed to remain in service [include pictures and information on extracted LSLs in supporting documents (SD)].

Where LSL replacement is required under the current LCR, a CWS that is triggered into LSL replacement is currently only required to remove the portions of the LSLs that they own. This process is called a partial lead service line replacement, which recent studies have shown can increase lead levels by disturbing or dislodging the protective scales within the LSLs. In addition, infrastructure maintenance activities, such as water main replacements, cause physical disturbances to LSLs which can result in the release of scale and sediment particles containing high lead concentrations from within LSLs. Lead-bearing particles are also released sporadically from within LSLs on a daily basis in many public water systems due to galvanic corrosion as a result of partial LSL replacement and the subsequent re-connection of the remaining portion of the lead pipe to new copper pipe. These lead-bearing particles often contain a very high percentage of lead by weight (xx – xx percent)[include ORD table in SD], far exceeding the 0.5 percent lead content defined by U.S. EPA for lead paint [include EPA definition in SD or citation(s) here]. The number of LSLs that are physically disturbed or partially removed during routine infrastructure work far exceeds the number of LSLs disturbed when LSLs are partially replaced under the LCR requirements [insert citation(s)] and there are currently no requirements in the LCR associated with LSLs that are disturbed or partially replaced in the course of routine infrastructure work.

In most typical communities, only a portion of the community has LSLs, but orthophosphate is applied centrally at one or more treatment plants to all of the water distributed throughout the community. Given the findings of the recent studies on lead levels and health effects, the continued presence of the LSLs in the community and the life expectancy of the LSLs that are currently in service may necessitate an increase in the amount of orthophosphate used at the treatment plant(s) on a permanent basis. This requires a community with LSLs to pay for a higher level of treatment than would be necessary if the community did not have LSLs, and the corresponding increase in phosphorus levels in the waste water can exacerbate efforts by communities to improve local water quality conditions. Degradation of water bodies in

Wisconsin that are used as drinking water sources could in turn require public water systems and other entities that utilize those sources to install new treatment or modify their existing treatment and operations as a result of the degraded water quality.

In addressing the risk posed by LSLs, it is essential that communities develop strategies to manage infrastructure in a sustainable manner, such that the overall long-term costs to communities is minimized.

> *"Drinking water and wastewater systems should use robust and comprehensive planning processes to pursue water infrastructure investments that are cost-effective over their life cycle, are resource efficient, and are consistent with community sustainability goals."*

The U.S. EPA and the WDNR have agreed on the need to better integrate implementation of the statutory and regulatory requirements under the Clean Water Act (CWA) and SDWA to protect public health and improve our nation's environment and the U.S. EPA is committed to protecting source waters from contamination that can adversely affect drinking water sources. [Include in SD: Water Supply Guidance 163 on Source Water Protection]

> *"I have directed my staff to continue CWA/SDWA integration actions that have been a priority for the past two years. The operating principle of these policy efforts is that, while public water systems are legally accountable for the delivery of safe drinking water to their consumers, no water system should have to provide more treatment than that which is necessary to address naturally occurring pollutant concentrations e.g., minerals leaching from rock formations, wildlife contamination unrelated to anthropogenic activities."*

The WDNR has therefore proposed an alternative approach which the WDNR believes will be more efficient than the current LCR treatment technique in lowering lead and copper levels. The WDNR proposes that this approach be allowed for certain CWSs in Wisconsin that meet specific criteria. Rather than continuing to maintain and potentially increase the amount of orthophosphate currently being used and needed to mitigate lead levels at consumers' taps, the WDNR proposes to focus on removing all LSLs in CWSs, along with a corresponding re-evaluation of existing State OCCT designations, with the intent of modifying the State-designated OCCT to eliminate or reduce the level of orthophosphate addition to the water supply where it is safe to do so. This approach would also provide CWSs with the ability to better plan and coordinate LSL replacement with infrastructure work which can result in cost efficiencies and significant cost savings for CWSs.

Consistent with U.S. EPA's sustainability policy [include policy in SD], the approach proposed by WDNR provides a more comprehensive and sustainable approach to public health protection and environmental protection by removing all LSLs in conjunction with other planned infrastructure improvements in a cost-efficient manner. Facilitating the removal of the entire length of all LSLs, including the resident-owned portions of the LSLs, would benefit all residents in the community by allowing the reduction or elimination of the use of orthophosphate and the associated costs to operate and maintain the treatment, which could provide a significant permanent cost savings to all residents of the CWS under both the SDWA and CWA. Elimination of the LSLs can also significantly reduce the complexity of compliance with other SDWA regulations.

Based on the recent health effects and LSL studies, interim measures will also be needed to protect pregnant women and children in homes that have LSLs. Training and educational material specific to the potential risks posed by LSLs in the community as well as the potential risks from LSLs and LSL disturbances are also needed to better inform those that provide care for the most vulnerable residents as well as the local childhood lead poisoning prevention programs for investigating water as a potential exposure source for children with elevated blood lead levels (EBLLs).

Removal of all LSLs would be necessary prior to considering any reduction in orthophosphate and decisions on how to structure and plan the LSL removal program are to be made within each community by the local authorities, water systems and residents, such that cost efficiencies can be realized and decisions on environmental justice issues can be made within the affected communities.

Corresponding changes would be made to the monitoring structure to assess the relative risks from the remaining lead sources in the community based on premise plumbing materials, to better inform residents as to the potential risks that are more specific to their homes (e.g., homes with copper pipes, galvanized iron pipes) and to assess the potential for reducing or eliminating the use of orthophosphate for corrosion control.

Once LSLs are fully removed from a system, the remaining sources of lead would be leaded-solder, leaded-brass and residual lead that has accumulated within premise plumbing from the LSLs. All three sources are expected to diminish over time as leaded-solder is no longer allowed to be sold or used for potable water applications, the prohibition on the sale and use of brass plumbing components became effective in January 2014, and with the removal of all LSLs, the LSLs will no longer be contributing lead to the premise plumbing. Consequently, once all LSLs are fully removed (portions owned by the CWS as well as the residents), a CWS may be able to significantly reduce or eliminate the use of orthophosphate for corrosion control, and use pH/alkalinity adjustment to control lead release from these sources.

The U.S. EPA and WDNR have concluded that successful projects demonstrate that in some cases, changes in U.S. EPA regulations, policies, guidance, or interpretations are needed to improve upon the nation's existing public health and environmental protection system. Where such changes can be made under existing law, U.S. EPA agrees to initiate the process for making the changes following applicable procedures. U.S. EPA, Region 5, has reviewed WDNR's proposal and believes that the proposal has merit and that the alternative treatment technique will be more efficient in lowering the level of lead and copper in drinking water than the specified treatment technique under the LCR and will realize public health benefits more quickly than proposed revisions to the LCR, which optimistically would begin to realize public health benefits from re-optimization of corrosion control treatment and/or LSL replacement in 2026 or beyond.

U.S. EPA has identified a variance, pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), as the appropriate legal mechanism for providing the regulatory flexibility which WDNR has requested. The variance allows certain CWSs to use the alternative treatment technique where specific conditions are met, in lieu of the treatment technique established under the current LCR. The variance establishes participation criteria that a CWS must meet in order to qualify for the alternative treatment technique. The variance also sets forth the performance criteria that the CWS must meet to continue to be allowed to use this alternative treatment technique. To ensure that the alternative treatment technique is as effective as possible, and provides at least an equivalent level of protection as the existing regulations, U.S. EPA and WDNR have entered into the "Memorandum of Understanding Between Wisconsin Department of Natural Resources and U.S. Environmental Protection Agency" (hereinafter "MOU") in Attachment X, describing the roles and responsibilities of each agency in implementing the variance. The MOU specifies State oversight requirements which WDNR must follow to insure the proper implementation of the variance and the use of this alternative treatment technique.

C. FINDINGS OF FACTS

1. This matter comes before the Regional Administrator of U.S. EPA, Region 5, on request by WDNR, for a State-wide variance pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3).

2. Pursuant to Section 1401(4)(A)of SDWA, 42 U.S.C. §300f(4)(A), a PWS is a system that provides drinking water to the public for human consumption through pipes or other constructed conveyances, and that has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

3. A CWS is a PWS which serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents.

4. Pursuant to Section 1401(1)(A) of SDWA, 42 U.S.C. §300f(1)(A), because CWSs and are PWSs, certain NPDWRs apply to CWSs.

5. The LCR requires all CWSs to comply with the regulatory requirements specified at 40 C.F.R. §141.80 through §141.91.

6. WDNR requests that a State-wide variance be granted, allowing CWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in this variance in lieu of complying with specific regulatory provisions outlined in the LCR.

D. CONCLUSIONS OF LAW

1. Section 1415 (a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), authorizes the U.S. EPA Administrator to grant a variance from a treatment technique of an NPDWR:

   "...upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."

2. Title 40 C.F.R. Part 142, Section 142.46 grants the U.S. EPA Administrator the authority to grant a variance from any treatment technique requirement of a national primary drinking water regulation to a supplier of water, whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility.

3. The authority to issue SDWA variances for treatment technique requirements was delegated to the Regional Administrators on June 12, 2000. Delegation 9-69, *Issuance of Variances for Treatment Technique Requirements*.

4. A CWS in Wisconsin will be eligible upon application to and approval by WDNR, for this variance only if the CWS meets the eligibility criteria and complies with all requirements specified in the "Community Water System Agreement" in Attachment A (hereinafter "Agreement") of this variance, and the MOU with WDNR MOU included in Attachment B and referenced in Section E is in effect.

5. The eligibility criteria and requirements specified in the Agreement constitute the alternative treatment technique and are hereby incorporated by reference.

5. CWSs shall implement the alternative treatment technique specified in the Agreement, in lieu of complying with the LCR requirements specified in [scope to be determined: §§141.80 through 141.82, 141.84, 141.86, 141.87 and 141.88].

E. MOU Between WDNR and U.S. EPA

U.S. EPA Region 5 and WDNR have entered into the MOU in Attachment B (hereby incorporated by reference), which will become effective upon the signing of this variance, and which describes each agency's responsibilities and commitments regarding the variance and the alternative treatment technique. WDNR will review and act on all submittals in accordance with the MOU established herein. Approval for the use of the alternative treatment technique for any CWS will be determined on a case-by-case basis by WDNR in accordance with the provisions of this variance and the MOU between EPA and WDNR.

The U.S. EPA will review the MOU and State reporting contained therein on an annual basis, to determine if all variance conditions and the terms and conditions of the MOU continue to be met. Following the promulgation of final revisions to the LCR, the U.S. EPA will review the variance criteria and conditions to determine whether the variance criteria and conditions require modification to continue to meet the requirements of SDWA Section 1415(a)(3).

F. ORDER

It is therefore ordered:

That in consultation with WDNR, the Regional Administrator, U.S. EPA, Region 5, finds that WDNR has made a showing for a variance under Section 1415(a)(3) of SDWA. WDNR's request for a State-wide variance is granted, subject to the following conditions:

1. All participating CWSs shall meet the eligibility criteria outlined the Agreement, and shall comply with all requirements specified in the Agreement.

2. Failure to comply with any requirement in the Agreement will automatically terminate the CWS eligibility for this variance. This variance shall also terminate:

   a) Upon termination of the MOU by either WDNR or U.S. EPA; or
   b) Upon a determination by U.S. EPA or WDNR that the alternative treatment technique no longer meets the requirements for equivalent lead reduction required under the provisions of Section 1415(a)(3) of SDWA.
   c) Upon a determination by U.S. EPA that the WDNR is not meeting the terms and conditions of the MOU.

6. In the event that the variance terminates, all CWSs subject to this variance shall be required to comply with all applicable requirements under the LCR beginning no later than [xx days] from the date of notification of the termination of the variance.

7. The Regional Administrator shall retain jurisdiction and shall annually review the circumstances pertaining to the variance, and may modify or revoke the variance for any CWS or for all CWSs if any provisions or conditions of the variance are not met.

8. Notwithstanding any other provision contained in this variance, the U.S. EPA may require any CWS to take such actions as deemed necessary to ensure that public health is protected.

9. Nothing in this Order alters or otherwise affects any requirement applicable under the State law.

Dated: ____________________

____
Susan Hedman, Regional Administrator
U.S. EPA, Region 5

EPA LOGO

Memorandum of Understanding
Between
Wisconsin Department of Natural Resources
And
U.S. Environmental Protection Agency

WDNR LOGO

A. Introduction

A Memorandum of Understanding (MOU) between the Wisconsin Department of Natural Resources (WDNR) and the U.S. Environmental Protection Agency (EPA) regarding an Alternative Treatment Technique for Reduction of Lead in Drinking Water under Safe Drinking Water Act (SDWA) Section 1415(a)(3).

WHEREAS, WDNR and U.S. EPA are mandated to protect public health from contaminants in drinking water under the Public Water System Supervision (PWSS) Program;

WHEREAS, WDNR has primary enforcement authority for the PWSS Program in Wisconsin;

WHEREAS, U.S. EPA has the authority to issue variances under SDWA Section 1415(a)(3);

WHEREAS, the U.S. EPA Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation to a supplier of water, whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility (40 CFR §142.46);

WHEREAS, the authority to issue variances under SDWA Section 1415(a)(3) has been delegated to the Regional Administrators;

WHEREAS, the U.S. EPA has determined that the use of the alternative treatment technique can achieve more efficient and permanent reductions in lead levels than the current treatment technique in the Lead and Copper Rule;

Now, **THEREFORE**, WDNR and U.S. EPA enter into this MOU.

A. Background

The WDNR and U.S. EPA Region 5 are mandated to protect human health and the environment, and acknowledge the need to better integrate implementation of CWA and SDWA provisions to promote sustainability and efficient use of community resources.

In order to protect public health from the harmful effects of lead in drinking water under the SDWA in a manner that will not adversely impact water quality under the CWA, the WDNR and U.S. EPA agree to provide communities in Wisconsin the opportunity to utilize a more efficient and permanent method for lowering lead in drinking water under the SDWA that does not result in adverse impacts on water quality or community compliance with regulatory requirements under the CWA.

B. Purpose

The purpose of this MOU is to set forth the commitments between the WDNR and U.S. EPA Region 5 for implementing and managing the variance designating an alternative treatment technique for the reduction of lead in drinking water for communities in Wisconsin.

The intent of the variance is to make a real difference in communities by increasing the level of protection of human health and the environment utilizing an alternative treatment technique that will be more efficient at permanently reducing lead levels in drinking water, more cost-effective over the long-term, and will realize human health benefits more quickly than under potential revisions to the Lead and Copper Rule. This effort with also promote the sustainability of communities by reducing or eliminating the use of phosphates at drinking water plants and corresponding discharges of phosphorus into the waters of Wisconsin, and eliminating a disincentive and potential obstacle to water conservation for homes with LSLs. A communications strategy will be developed to ensure effective communication with residents and transparency in government decision-making as directed in Executive Order [xxx] which pertains to all federal agencies.

C. Goals

The main goals established by WDNR and U.S. EPA Region 5 are to:

1. Realize significantly improved human health protection more quickly than waiting for regulatory revisions by implementing interim mitigation efforts that are not required by the current LCR;
2. Realize permanent significant reductions in lead levels by removing all partial and full LSLs, which are the largest sources of lead in drinking water distribution systems;
3. Provide significant cost reductions for LSL removal by allowing communities to plan and coordinating the removal of LSLs with other infrastructure work to make the most efficient use of limited community resources;
4. Remove barriers to water conservation;
5. Reduce and possibly eliminate the use of phosphates for drinking water treatment; and
6. Promote transparency in the government decision-making process.

D. Authorities and Limitations

The U.S. EPA has delegated primary enforcement authority for the Public Water System Supervision program to the WDNR, and the U.S. EPA Region 5 Office has been delegated the authority to issue variances under the SDWA Section 1415(a)(3) to specify alternative treatment techniques which achieve more efficient contaminant reduction than treatment techniques specified in National Primary Drinking Water Regulations.

Nothing in this MOU shall alter or modify any other compliance requirements under the SDWA or CWA except as allowed and specified in the variance and system agreements. Where unanticipated conflicts between regulatory requirements and the requirements of the variance should arise, the WDNR and U.S. EPA agree to work together to resolve these issues, and to modify the elements of the individual system agreements if necessary to resolve the conflicts in a manner which is consistent with all applicable requirements under the SDWA and CWA and the intent of the variance.

E. Commitments

The WDNR and U.S. EPA Region 5 commit to:

- Appoint a designated contact for implementation of this MOU. The designated individuals will meet at least semi-annually or at the request of either agency to review and discuss implementation of the variance. The WDNR designated contact is [name and/or title], and the EPA designated contact is [name and/or title], or as each designee delegates.
- Implement the variance consistent with U.S. EPA policies and guidance on transparency (Attachment A), sustainability (Attachment B), and source water protection (Attachment C).
- Provide support for, and attend community meetings to inform the residents in communities that elect to utilize the alternative treatment technique.
- Provide ongoing technical assistance to communities that elect to utilize the alternative treatment technique.

F. Additional Commitments by WDNR:

- Establish legally-binding agreements with CWSs in accordance with the required elements in the Community Water System Agreement specified in the Attachment A of the variance.
- Maintain a list of CWSs that have signed agreements.
- Maintain records of all reportable information specified in the CWS Agreements for each participating CWSs for a period that is not less than [xx] years following the completion of the removal of all LSLs in the CWS.
- Evaluate CWS compliance with the variance Agreement for each CWS no less frequently than annually.
- Provide an annual report to U.S. EPA which contains updated information for each participating CWS as specified in Attachment D to this MOU.
- Report to EPA, as soon as practicable, but not later than [30] days from learning of any CWS's failure to comply with any agreement requirement(s).
- Maintain an information repository with all variance-related documents, including the annual reports, which is readily accessible to the public.

G. Additional Commitments by U.S. EPA:

- Develop informational brochure templates for care local care providers and residents on the potential risks posed by LSLs.
- Maintain a website with information for residents on how to find LSLs, and steps that residents can take to reduce their lead exposure, including how to find and purchase lead-free plumbing components.
- Provide technical assistance to communities on interim mitigation efforts.

- Provide technical assistance to communities for evaluating the feasibility of reducing or eliminating the use of phosphates for corrosion control and secondary water quality issues. Provide laboratory support for assessing and evaluating sources of lead that will remain in premise plumbing.
- Review annual progress and compliance reports submitted by WDNR.

H. Other Provisions:

This MOU becomes effective upon the final signature of the parties listed below and is to remain in effect for [period of time], after which the parties are to discuss an extension of the MOU for mutual benefit. This MOU may be modified at any time per the mutual consent of the parties and with notice provided to all participating CWSs. Additionally, each party may terminate its participation in this MOU by providing written notice to the other party at least ninety (90) days prior to the desired termination date. In the event that the MOU is terminated by either party, the variance shall also be terminated and CWSs will be required to comply with all applicable provisions of 40 CFR Part 141, Subpart I (Lead and Copper Rule) beginning no later than [xx days] following the termination of this MOU and the associated variance.

Susan Hedman, Regional Administrator U.S. Environmental Protection Agency	[Name], Secretary Wisconsin Department of Natural Resources
Date	Date

Attachments A through C – to be attached

Attachment D – Annual Reports to U.S. EPA Region 5

[insert reportable information once CWS Agreement has been finalized]

LCR Alternative Treatment Technique
Community Water System Agreement

[The requirements/elements in this Agreement would be incorporated into a WDNR-issued consent order]

LEGAL AUTHORITY AND COMMITMENT

Agreement Number: _______________

An agreement between the [Entity e.g., City/Village/Town] of ____________, __________ County, Wisconsin, and the Wisconsin Department of Natural Resources to implement the Alternative Treatment Technique for Lead Reduction in Drinking Water.

WHEREAS, the [Entity] of ___________________________, _____________County, Wisconsin, operates a Community Water System ("System") in accordance with the provisions of the [Wisconsin Administrative Code];

WHEREAS, [Legally responsible person(s)] of [Entity] have determined that it is advisable, necessary, and in the best interest of the public health, safety, and welfare to fully remove all lead service lines (LSLs), including the privately-owned portions of such lines;

WHEREAS, the Secretary of the WDNR has signed a Memorandum of Understanding with U.S. EPA Region 5 to oversee implementation of the alternative treatment technique;

Now THEREFORE, be it ordained by [Legally responsible person(s)] of [Entity] of ___________________________, ______________ County, Wisconsin, that [Entity] hereby willingly enters into this Agreement with the WDNR and shall comply with all of the requirements specified in this Agreement, with the full understanding that this is a legally binding Agreement.

1. Communication Strategy

[Entity] shall implement a strategy for ongoing communication with residents, health care providers, local health departments and other organizations as specified and approved by the WDNR. Specifically, [Entity] shall:

a. Coordinate the distribution of educational material on lead in drinking water, the risk posed by LSLs, the importance of following interim mitigation actions, and information on the LSL replacement program with local health care providers, local health departments, lead poisoning prevention organizations, and any other organizations specified by the WDNR.
b. No later than [date/timeline], [Entity] shall provide notices and educational material on LSLs and the risks posed by lead and LSLs to all residents that could potentially have LSLs, based on the assessment criteria established in Section 2 of this Agreement, and any other entities specified by the WDNR. The educational material must contain all information available as to the locations, or potential locations of all LSLs and partial LSLs, and shall include the important notice specified in paragraph c (below).
c. On an annual basis, provide a special notice on the front page of the Consumer Confidence Report with information regarding the LSLR program:

Important Notice: Some homes in our community are connected to the water main with lead pipes which can pose a significant health risk to pregnant women, infants and children. Recent studies have shown that these lead lines can release high levels of lead. [Entity] has determined that the best course of action to protect public health in our community is to remove these lead lines. It will take time to remove all of the lead lines so in the interim, [Entity] is providing water filters to homes with lead lines. If your home is connected to the water main with a lead pipe, and you have not received a water filter from [Entity], please contact [name] at [number] or [email address].You can find more information on lead lines, including how to determine whether you have a lead pipe on the following website: [WDNR or U.S. EPA website]. [Optional?: You can also request that a representative of [Entity] come and check your home.]

d. Ensure that information is available to residents in a readily accessible and easy to understand manner, such as on a publicly accessible CWS website.
e. [Additional WDNR requirements?]

2. Service Line Inventories (Materials Survey and Verification of LSLs)

[Entity] shall complete the following inventory activities:

a. Report all known partial and full LSLs to WDNR within [xx days] from the date of the signed Agreement.
b. Implement WDNR-approved procedures for identifying and verifying the LSL inventory, including any LSLs or portions of LSLs not owned by the PWS, no later than [deadline]. These procedures shall take into account that some LSLs may have been illegally installed after local ban on LSLs and shall prioritize the inventory and verification of LSLs at schools, child care facilities, and areas of the community with highest EBLLs.
c. Complete a full inventory of all partial or full lead service lines within the community no later than [xx years] from the date of the final, signed Agreement.
d. Record the service line material for each home, during any home visits, such as to install, repair or replace water meters.
e. [Additional WDNR requirements?]

3. Interim mitigation efforts

[Entity] shall implement the following interim mitigation activities:

a. Prioritize all interim mitigation measures, including distribution of water filters to schools, childcare facilities, and areas of the community with the highest EBLLs.
b. Distribute one water filter to each home with a LSL or partial LSL within [xx days] of verifying the presence of a LSL or partial LSL, and continue to provide replacement filters or cartridges (as applicable) until [xx years] following the removal of all portions of the LSL, based on the results of sampling at representative homes where LSLs have been removed, indicating that lead levels are consistent with homes that did not have LSLs. The water filter must be certified by an ANSI accredited organization for lead removal. Water filters may be used solely as an interim mitigation measure for CWSs that have committed to remove all LSLs. In no case may a CWS use point-of-use (POU) devices on a permanent basis or for longer than [xx years], unless a CWS is eligible to use POU devices in accordance with, and complies with all applicable requirements for

Commented [MDT1]: To be specified by WDNR.

Commented [MDT2]: To be specified by WDNR based on the number of LSLs, the size of the CWS and any other planned infrastructure work.

Commented [MDT3]: To be specified by WDNR based on the number of LSLs, the size of the CWS.

Commented [MDT4]: To be specified by WDNR.

POU devices used as small system compliance technologies in [WDNR equivalent of EPA Small System Compliance Technology requirements].

c. Distribute brochures or post links on website LSLR program website, including link to U.S. EPA brochure on how to identify 2014 lead-free components for residents.
d. Provide information to local building/plumbing regulators on the materials restrictions and LSLR program.
e. Provide all residents with periodic aerator cleaning and flushing reminders.
f. [Additional WDNR requirements?]

4. LSL Replacement Schedule and Timeline

[Entity] shall implement the following LSL replacement activities:

a. Remove all LSLs, including any LSLs or portions of LSLs not owned by the PWS, within the timeframe designated by WDNR, not to exceed [xx years]. A full inventory need not be complete to begin LSLR. The time allowable shall be commensurate with the size of the CWS and the number of LSLs within the CWS. At WDNR discretion, the schedule shall allow for consolidation of the LSLR program with other planned infrastructure work. In no case shall the allowable time exceed [xx years; or xx years per xxx LSLs?].
b. Prioritize the removal of LSLs at schools, child care facilities, areas of the community with highest EBLLs and homes that have been unoccupied for extended periods of time.
c. Where [Entity] is combining the LSL replacement program with other infrastructure work, demonstrate to the satisfaction of the WDNR, that [Entity] has made an irrevocable financial commitment to complete such work.
d. For each site with a LSL or partial LSL, remove all portions of LSLs from the water main to the foundation of the building or to the first internal connection (e.g., meter).
e. [Additional WDNR requirements?]

Commented [MDT5]: EPA needs to specify a timeframe here after discussions with WDNR.

Commented [MDT6]: EPA needs to specify a timeframe here after discussions with WDNR.

5. Monitoring Requirements for Lead and Copper

a) Option 1: PWS collects samples at non-LSL sites in lieu of LSL sites (assuming filters are provided to all LSL homes) in accordance with the standard/reduced number of sites in the LCR. Sample results are used by WDNR to determine if any corrective actions are necessary.
b) Option 2: PWS establishes a resident-requested sampling program. Sample results are used to inform residents on results based on different types of premise plumbing, and used by WDNR to determine if any corrective actions are necessary.
c) Other?

6. Treatment Maintenance

[Entity] shall continuously operate and maintain the State-designated Optimal Corrosion Control Treatment (OCCT) in place at the time of signing of this Agreement and shall also:

a. Conduct treatment process control monitoring as specified by the WDNR to ensure that existing corrosion control treatment is maintained until such time as the WDNR has approved any corrosion control treatment modification in accordance with Section 7 of this Agreement.
b. [Additional WDNR requirements?]

7. Reduction of PO4 (Process)

a. [Entity] shall conduct and submit a corrosion control study to WDNR, and receive written approval from WDNR prior to making any proposed modifications to the WDNR-designated OCCT.
b. Should the WDNR allow a modification to OCCT which allows a reduction of the level of orthophosphate as a result of corrosion control study, [Entity] agrees not to re-install any leaded-brass components such as existing water meters, intended for use in potable water applications.
c. [Corrective actions TBD should lead levels begin to increase.]

8. **PWS Reporting and Recordkeeping Requirements** [Many 141.90 and 141.91 elements are not applicable since we are not using LCR TT – changes are needed to correspond to differences between variance requirements and LCR]
   [Entity] shall comply with the following recordkeeping and reporting requirements:

   a. Entity shall maintain the following records for the amount of time specified for each: [Recordkeeping requirements TBD]
   b. Entity shall report the following information by the specified deadline:
      1) Notify WDNR of any individual lead results that exceed 0.015 mg/L within [xx days].
      2) [General reporting requirements TBD]
   c. Annual progress reports shall be submitted by [Entity], including the following information:
      1) Monitoring results for all lead and copper and process control monitoring required in accordance with this Agreement.
      2) The number of full LSLs and the number of partial LSLs removed, including the addresses for each site where a full or partial LSL has been removed and whether a full or partial LSL was removed.
      3) A signed certification that [Entity] remains in compliance with all variance and Agreement requirements.
      4) [Additional reporting requirements?]
   d. Any additional documents and/or information requested by WDNR or U.S. EPA as may reasonably be needed to determine [Entity's] compliance with this Agreement and to ensure that public health is adequately protected.

If any event occurs that causes or is likely to cause delay in the achievement of any requirement of this Agreement within any time frame specified in this Agreement, the CWS shall notify the WDNR in writing, within [xx days] of learning of the actual or likely delay, of the anticipated length and cause of the delay, the measures taken, or to be taken, to prevent or minimize the delay, and the timetable by which the CWS intends to implement these measures and achieve the requirement. In such a case, the CWS shall adopt all reasonable measures to avoid or minimize delay. Submittal of the notice to WDNR required by this paragraph does not extend any deadline or time frame in this Agreement. This Agreement does not relieve [Entity] of any responsibilities or liabilities established pursuant to any applicable local, state, or federal law.

This agreement becomes effective upon the final signature of the parties listed below and is to remain in effect for a period of time not to exceed [xx years]. This agreement may not be modified without written approval from the WDNR. Any CWS that fails to comply with all requirements of the variance and this Agreement shall comply with all applicable requirements in [DNR equivalent of LCR] no later than [xx days] following termination of this Agreement in writing by the WDNR.

The provisions of this Agreement shall be binding upon [Entity], their officers, directors, agents, servants, authorized representatives and successors or assigns. The undersigned representatives of [Entity] each certify that they are fully authorized to enter into the terms and conditions of this Agreement and to bind the [Entity] to this Agreement, and [Entity] hereby agrees to comply with and implement all provisions of this Agreement.

[Authorized CWS Official]	[Authorized WDNR Official]
[CWS Name]	Wisconsin Department of Natural Resources
Date	Date

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
(U.S. EPA) REGION 5

IN THE MATTER OF:

Alternative Treatment Technique for Reduction of Lead in Drinking Water for Wisconsin Communities	**)) VARIANCE UNDER SECTION UNDER) SECTION 1415(A)(3) OF SDWA)**

____

INTRODUCTION

A. Statutory and Regulatory Background

Under the Safe Drinking Water Act (SDWA), 42 U.S.C. §§300f-300j-26, U.S. EPA promulgates national primary drinking water regulations (NPDWRs), which specify for certain drinking water contaminants either a maximum level or treatment technique with which public water systems, including community water systems (CWSs) must comply. U.S. EPA has promulgated an NPDWR for lead and copper, the Lead and Copper Rule (LCR), 40 C.F.R. Part 141, Subpart I, that includes a treatment technique which consists of multiple components, requiring CWSs and non-transient non-community water systems (NTNCWS) to take various steps to ensure that users of their system are not exposed to levels of lead and/or copper in drinking water that would result in adverse health effects. Although the LCR applies to both NTNCWSs and CWSs, these system types have many significant differences and this variance focuses on CWSs and the unique challenges posed by the LCR to CWSs. The LCR requires all CWSs to optimize corrosion control and to conduct tap water monitoring to ensure that lead and copper levels are minimized at users' taps. If tap water levels exceed either 'action level' (AL) of 0.015 mg/L for lead or 1.3 mg/L for copper, in more than 10 percent of drinking water tap samples (i.e., exceeds the AL as a 90th percentile value), CWSs are required to take additional steps, including delivering public education materials to users explaining the health risks from lead in drinking water (for lead AL exceedances), treating source water if it contains elevated lead and/or copper levels, or installing optimal corrosion control treatment (OCCT) for CWSs that were considered to have optimized corrosion control without having installed treatment. For systems that continue to exceed the lead AL after installing OCCT, the system must begin replacing at least seven percent of lead service lines (LSLs) in the system per year. LSLs that contribute less than 0.015 mg/L of lead do not need to be replaced and can be counted toward the number of LSLs required to be replaced.

The Wisconsin Department of Natural Resources (WDNR) has primary enforcement responsibility for administering the LCR because it has adopted regulations that are at least as stringent as the federal regulations (see Wisconsin Administrative Code NR 809 Subchapter II). The State regulation currently applies to all CWSs in Wisconsin. The U.S. EPA has the authority to grant a variance from any treatment technique upon a showing by any person that the alternative treatment technique is at least as efficient in lowering the level of that contaminant in drinking water. Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), provides:

> *"The Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."*

See also 40 C.F.R. §142.46.

B. Factual Background

The LCR requires that all CWSs optimize corrosion control to minimize lead and copper levels at consumers' taps. Many CWSs currently utilize orthophosphate as the primary lead and copper corrosion control mechanism. The addition of orthophosphate has been effective at reducing lead and copper levels in drinking water under the SDWA. However, recent studies on CWSs with LSLs indicate that the current sampling protocol in the LCR can significantly underestimate lead levels and many CWSs have lead levels that are much higher than previously believed. Studies conducted on the adverse health effects from lead since the original LCR was promulgated continue to reaffirm that there is no safe level of lead exposure and that even low lead levels cause harm. Consequently, the current level of treatment may be insufficient to protect public health in many CWSs, and it may be necessary for CWSs with LSLs to significantly increase the level of orthophosphate needed to reduce lead levels in the drinking water. The available options for effectively reducing lead and copper levels in CWSs with LSLs without the use of orthophosphate are very limited, potentially requiring significant capital improvements as well as other water quality and operational changes due to the public health risk posed by the LSLs and the life expectancy of the LSLs.

The allowable discharge limits for phosphorus into receiving waters are being lowered under the Clean Water Act (CWA) in Wisconsin such that the amount of orthophosphate that may be needed to effectively reduce lead levels in drinking water as part of the OCCT for SDWA compliance would require certain entities under the CWA to install treatment to remove the phosphorus prior to being able to discharge into receiving waters even where they have added none of the phosphorus themselves (e.g., entities using potable water in non-contact cooling water applications that is discharged to receiving waters). Many of the same entities regulated under both the CWA and SDWA must comply with lead in drinking water reductions under the SDWA and phosphorus discharge limits under the CWA. To satisfy the regulatory requirements under both statutes, a community with LSLs may be required to increase the level of orthophosphate at the drinking water plant in order to protect public health from lead in drinking water under the SDWA, which will increase the level of phosphorus in the waste water, while also working to achieve compliance with reduced phosphorus discharge limits into receiving waters under the CWA.

Almost all lead and copper comes from plumbing materials transporting drinking water to the homes via the distribution system and from plumbing within the homes themselves, therefore there is no possibility to remove these contaminants at the drinking water treatment plant. A SDWA ban on the use of leaded solder and other leaded plumbing materials became effective in 1986 with subsequent additions and modifications to the law since then. It is no longer permissible to install new leaded materials in potable water applications within a CWS or premise plumbing. While the SDWA prohibits the introduction of most leaded materials into the plumbing network, it does not require the removal of existing lead sources. LSLs, leaded brass and to a more limited extent leaded solder continue to leach lead into the drinking water, with the largest individual source being LSLs where they are present. LSLs can contribute up to 75 percent of the total lead mass in the drinking water and the lead that is released from LSLs can also accumulate in premise plumbing. It is estimated that there are approximately 10 million full or partial lead service lines currently in service in CWSs. Many extracted LSLs that had been in use for over 100 years show no signs of degradation and it is expected that existing LSLs still in service can easily last another 100 years without appreciable degradation if they are allowed to remain in service.

Where LSL replacement is required under the current LCR, a CWS that is triggered into LSL replacement is currently only required to remove the portions of the LSLs that they own. This process is called a partial lead service line replacement, which recent studies have shown can increase lead levels by disturbing or dislodging the protective scales within the LSLs. In addition, infrastructure maintenance activities, such as water main replacements, cause physical disturbances to LSLs which can result in the release of scale and sediment particles containing high lead concentrations from within LSLs. Lead-bearing particles are also released sporadically from within LSLs on a daily basis in many public water systems due to galvanic corrosion as a result of partial LSL replacement and the subsequent re-connection of the remaining portion of the lead pipe to new copper pipe. These lead-bearing particles often contain a very high percentage of lead by weight (68 to 98 percent), far exceeding the 0.5 percent lead content defined by U.S. EPA for lead paint. The number of LSLs that are physically disturbed or partially removed during routine infrastructure work far exceeds the number of LSLs disturbed when LSLs are partially replaced under the LCR requirements and there are currently no requirements in the LCR associated with LSLs that are disturbed or partially replaced in the course of routine infrastructure work.

In most typical communities, only a portion of the community has LSLs, but orthophosphate is applied centrally at one or more treatment plants to all of the water distributed throughout the community. Given the findings of the recent studies on lead levels and health effects, the continued presence of the LSLs in the community and the life expectancy of the LSLs that are currently in service may necessitate an increase in the amount of orthophosphate used at the treatment plant(s) on a permanent basis. This requires a community with LSLs to pay for a higher level of drinking water treatment than would be necessary if the community did not have LSLs, and the corresponding increase in phosphorus levels in the waste water can exacerbate efforts by communities to improve local water quality conditions. Degradation of water bodies in Wisconsin that are used as drinking water sources could in turn require public water systems and other entities that utilize those sources to install new treatment or modify their existing treatment and operations as a result of the degraded water quality.

In addressing the risk posed by LSLs, it is essential that communities develop strategies to manage infrastructure in a sustainable manner, such that the overall long-term costs to communities is minimized.

> *"Drinking water and wastewater systems should use robust and comprehensive planning processes to pursue water infrastructure investments that are cost-effective over their life cycle, are resource efficient, and are consistent with community sustainability goals."*
> (*EPA's Clean Water and Drinking Water Infrastructure Sustainability Policy)*

The U.S. EPA and the WDNR have agreed on the need to better integrate implementation of the statutory and regulatory requirements under the Clean Water Act (CWA) and SDWA to protect public health and improve our nation's environment and the U.S. EPA is committed to protecting source waters from contamination that can adversely affect drinking water sources.

> *"I have directed my staff to continue CWA/SDWA integration actions that have been a priority for the past two years. The operating principle of these policy efforts is that, while public water systems are legally accountable for the delivery of safe drinking water to their consumers, no water system should have to provide more treatment than that which is necessary to address naturally occurring pollutant concentrations e.g., minerals leaching from rock formations, wildlife contamination unrelated to anthropogenic activities."*
> – G. Tracy Mehan III, Assistant Administrator for Water

The U.S. EPA and WDNR also agree that solutions to public health and environmental problems must also incorporate the principles outlined in Presidential Order 12898 on Environmental Justice.

> *"To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands."*
> *-Executive Order 12898 (February 11, 1994)*

> *"Every American deserves clean air, water and land in the places where they live, work, play and learn. Through our implementation of Plan EJ 2014, the EPA will be leading by example in expanding the conversation on environmentalism and*

working for environmental justice – now and into the future."
-Lisa Jackson, U.S. EPA Administrator

EPA is also committed to the principles outlined in the President's Memorandum on Transparency and Open Government:

"Government should be transparent. Transparency promotes accountability and provides information for citizens about what their Government is doing. Information maintained by the Federal Government is a national asset. My Administration will take appropriate action, consistent with law and policy, to disclose information rapidly in forms that the public can readily find and use. Executive departments and agencies should harness new technologies to put information about their operations and decisions online and readily available to the public. Executive departments and agencies should also solicit public feedback to identify information of greatest use to the public.

"Government should be participatory. Public engagement enhances the Government's effectiveness and improves the quality of its decisions. Knowledge is widely dispersed in society, and public officials benefit from having access to that dispersed knowledge. Executive departments and agencies should offer Americans increased opportunities to participate in policymaking and to provide their Government with the benefits of their collective expertise and information. Executive departments and agencies should also solicit public input on how we can increase and improve opportunities for public participation in Government.

"Government should be collaborative. Collaboration actively engages Americans in the work of their Government. Executive departments and agencies should use innovative tools, methods, and systems to cooperate among themselves, across all levels of Government, and with nonprofit organizations, businesses, and individuals in the private sector. Executive departments and agencies should solicit public feedback to assess and improve their level of collaboration and to identify new opportunities for cooperation."
(Memorandum for the Heads of Executive Departments and Agencies-January 21, 2009)

WDNR Proposal

Rather than continuing to maintain and potentially increase the amount of orthophosphate currently being used and needed to mitigate lead levels at consumers' taps, the WDNR proposes to focus on removing all LSLs in CWSs, along with a corresponding re-evaluation of existing State OCCT designations, with the intent of modifying the State-designated OCCT to eliminate or reduce the level of orthophosphate addition to the water supply where it is safe to do so. The WDNR proposes that this approach be allowed for certain CWSs in Wisconsin that meet specific criteria. The WDNR believes this alternative approach will be at least as efficient as the current LCR treatment technique in lowering lead and copper levels in drinking water.

This approach would also provide CWSs with the ability to better plan and coordinate LSL replacement with other planned infrastructure improvements, like water main replacement or sewer work, which can result in cost efficiencies and significant cost savings for CWSs. This is consistent with U.S. EPA's sustainability policy, as it provides a more comprehensive and sustainable approach to public health protection and environmental protection.. Facilitating the removal of the entire length of all LSLs, including the resident-owned portions of the LSLs, would benefit all residents in the community by allowing the reduction or elimination of the use of orthophosphate and the associated costs to operate and maintain the treatment, which could provide a significant permanent cost savings to all residents of the CWS under both the SDWA and CWA. Elimination of the LSLs can also significantly reduce the complexity of compliance with other SDWA regulations.

Based on the recent health effects and LSL studies reaffirming the harm from lead and highlighting that lead levels in LSLs can be significantly higher than previously known, interim measures will also be needed to protect pregnant women and children in homes that have LSLs. Training and educational material specific to the potential risks posed by LSLs in the community as well as the potential risks from LSLs and LSL disturbances are also needed to better inform those that provide care for the most vulnerable residents as well as the local childhood lead poisoning prevention programs for investigating water as a potential exposure source for children with elevated blood lead levels (EBLLs).

The use of interim protective measures also allows communities to begin evaluating the potential for reducing orthophosphate levels once the interim measures are in place. Removal of all LSLs would not be necessary prior to considering any reduction in orthophosphate as residents in homes with LSLs will be provided water filters and aggressive public education on LSLs and the importance of using the filters. Decisions on how to structure and plan the LSL removal program are to be made within each community by the local authorities, water systems and residents, such that cost efficiencies can be realized and decisions on environmental justice issues can be made within the affected communities. Once all residents with LSLs have been identified and provided water filters to protect their families, a CWS can begin to evaluate reducing or eliminating the use of orthophosphate for corrosion control, and the potential for using pH/alkalinity adjustment as an alternative to orthophosphate to control lead release from remaining lead sources.

Along with the interim measures, conforming changes to the monitoring structure are necessary since the LCR would require CWSs with LSLs to collect samples at LSL sites, all of which would be using water filters. A modified monitoring program is therefore needed to assess the relative risks from the remaining lead sources in the community based on premise plumbing materials, to better inform residents as to the potential risks that are more specific to their homes (e.g., homes with copper pipes, galvanized iron pipes) and to assess the potential for reducing or eliminating the use of orthophosphate for corrosion control.

Once LSLs are fully removed from a system, the remaining sources of lead would be leaded-solder, leaded-brass and residual lead that has accumulated within premise plumbing from the LSLs. All three sources are expected to diminish over time as leaded-solder is no longer allowed to be sold or used for potable water applications, the prohibition on the sale and use of brass plumbing components became effective in January 2014, and with the removal of all LSLs, the LSLs will no longer be contributing lead to the premise plumbing. Consequently, a CWS may be able to significantly reduce or eliminate the use of orthophosphate for corrosion control, as many CWSs that do not have LSLs currently use pH/alkalinity adjustment to successfully control lead release from these sources.

The U.S. EPA and WDNR have concluded that changes can be made under existing law, and the U.S. EPA agrees to initiate the process for making the changes following applicable procedures. U.S. EPA, Region 5, has reviewed WDNR's proposal and believes that the proposal has merit and that the alternative treatment technique will be at least as efficient in lowering the level of lead and copper in drinking water than the specified treatment technique under the current LCR.

U.S. EPA has identified a variance, pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), as the appropriate legal mechanism for providing the regulatory flexibility which WDNR has requested. The variance allows certain CWSs to use the alternative treatment technique, where specific conditions are met, in lieu of the treatment technique established under the current LCR. The variance establishes participation criteria that a CWS must meet in order to qualify for the alternative treatment technique. The variance also sets forth the performance criteria that the CWS must meet to continue to be allowed to use this alternative treatment technique. To ensure that the alternative treatment technique is as effective as possible, and provides at least an equivalent level of protection as the existing regulations, U.S. EPA and WDNR have entered into the "Memorandum of Understanding Between Wisconsin Department of Natural Resources and U.S. Environmental Protection Agency" (hereinafter "MOU") as Attachment B to this variance, describing the roles and responsibilities of each agency in implementing the variance. The MOU specifies State oversight requirements which WDNR must follow to insure the proper implementation of the variance and the use of this alternative treatment technique.

C. FINDINGS OF FACTS

1. This matter comes before the Regional Administrator of U.S. EPA, Region 5, on request by WDNR, for a State-wide variance pursuant to Section 1415(a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3).

2. Pursuant to Section 1401(4)(A)of SDWA, 42 U.S.C. §300f(4)(A), a PWS is a system that provides drinking water to the public for human consumption through pipes or other constructed conveyances, and that has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

3. A CWS is a PWS which serves at least 15 service connections used by year round residents or regularly serves at least 25 year-round residents.

4. Pursuant to Section 1401(1)(A) of SDWA, 42 U.S.C. §300f(1)(A), because CWSs are PWSs, all NPDWRs apply to CWSs.

5. The LCR is a NPDWR that requires all CWSs to comply with the regulatory requirements specified at 40 C.F.R. §141.80 through §141.91.

6. WDNR requests that a State-wide variance be granted, allowing CWSs meeting specific qualifying criteria to use the alternative treatment technique outlined in Attachment A (Community Water System Agreement) in lieu of complying with specific regulatory provisions outlined in the LCR.

D. CONCLUSIONS OF LAW

1. Section 1415 (a)(3) of SDWA, 42 U.S.C. §300g-4(a)(3), authorizes the U.S. EPA Administrator to grant a variance from a treatment technique of an NPDWR:

   "...upon a showing by any person that an alternative treatment technique not included in such requirement is at least as efficient in lowering the level of the contaminant with respect to which such requirement was prescribed. A variance under this paragraph shall be conditioned on the use of the alternative treatment technique which is the basis for the variance."

2. Title 40 C.F.R. Part 142, Section 142.46 grants the U.S. EPA Administrator the authority to grant a variance from any treatment technique requirement of a national primary drinking water regulation to a supplier of water, whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility.

3. The authority to issue SDWA variances for treatment technique requirements was delegated to the Regional Administrators on June 12, 2000. Delegation 9-69, *Issuance of Variances for Treatment Technique Requirements*.

4. A CWS in Wisconsin will be eligible upon application to and approval by WDNR, for this variance only if the CWS meets the eligibility criteria specified in the order (Section F.1) and complies with all requirements specified in the "Community Water System Agreement" in Attachment A (hereinafter "Agreement") of this variance, and the MOU with WDNR included in Attachment B and referenced in Section E remains in full effect.

5. CWSs shall implement the alternative treatment technique specified in the Agreement, in lieu of complying with the LCR requirements specified in 40 CFR Part 141 Subpart I, unless otherwise specified in the Agreement.

E. MOU Between WDNR and U.S. EPA

U.S. EPA Region 5 and WDNR have entered into the MOU in Attachment B (hereby incorporated by reference), which will become effective upon the signing of this variance, and which describes each agency's responsibilities and commitments regarding the variance and the alternative treatment technique. WDNR will review and act on all submittals in accordance with the MOU established herein. Approval for the use of the alternative treatment technique for any CWS will be determined on a case-by-case basis by WDNR in accordance with the provisions of this variance and the MOU between EPA and WDNR.

The U.S. EPA will review the MOU and State reporting contained therein on an annual basis, to determine if all variance conditions and the terms and conditions of the MOU continue to be met. Should revisions to the LCR be promulgated in the future, the U.S. EPA will review the variance criteria and conditions to determine whether the variance criteria and conditions require modification to continue to meet the requirements of SDWA Section 1415(a)(3).

F. ORDER

It is therefore ordered:

That in consultation with WDNR, the Regional Administrator, U.S. EPA, Region 5, finds that WDNR has made a showing for a variance under Section 1415(a)(3) of SDWA. WDNR's request for a State-wide variance is granted, subject to the following conditions:

1. All participating CWSs shall meet all eligibility criteria outlined in this paragraph (F.1.a through F.1.x), and shall comply with all requirements specified in the Agreement. The requirements specified in the Agreement constitute the alternative treatment technique and are hereby incorporated by reference.

    a. The CWS must demonstrate to the satisfaction of the WDNR that the CWS retains the legal authority to remove or require the removal of all LSLs and portions of LSLs within the public water system, including all privately-owned portions of LSLs.
    b. The CWS must enter into a legally-binding Agreement with the WDNR to remove all LSLs and portions of LSLs within the distribution system, including all privately-owned portions of any LSLs, within the timeframe specified in the Agreement.
    c. Not later than 90 days following the signing of this agreement, the CWS must notify any public water systems to which they sell water of the intent to request a modification to their existing state-designated OCCT.
    d. The CWS must sign a legally binding Agreement, committing to implementation of all applicable requirements contained in the Agreement.
    e. [Additional WDNR criteria?]

2. Failure to comply with any condition, criteria or requirement in this order or in the Agreement will automatically terminate the CWS eligibility for this variance. This variance shall also terminate:

    a. Upon termination of the MOU by either WDNR or U.S. EPA; or

b. Upon a determination by U.S. EPA or WDNR that the alternative treatment technique no longer meets the requirements for equivalent lead reduction required under the provisions of Section 1415(a)(3) of SDWA; or
c. Upon a determination by U.S. EPA that the WDNR is not meeting the terms and conditions of the MOU.

3. In the event that the variance terminates, all CWSs subject to this variance shall be required to comply with all applicable requirements under the LCR beginning no later than [xx days] from the date of notification of the termination of the variance.

4. The Regional Administrator shall retain jurisdiction and shall annually review the circumstances pertaining to the variance, and may modify or revoke the variance for any CWS or for all CWSs if any provisions or conditions of the variance are not met.

5. Notwithstanding any other provision contained in this variance, the U.S. EPA may require any CWS to take such actions as deemed necessary to ensure that public health is protected.

6. Nothing in this Order alters or otherwise affects any requirement applicable under the State law.

Dated:

Susan Hedman, Regional Administrator
U.S. EPA, Region 5

EPA LOGO

Memorandum of Understanding Between Wisconsin Department of Natural Resources And U.S. Environmental Protection Agency

WDNR LOGO

A. Introduction

A Memorandum of Understanding (MOU) between the Wisconsin Department of Natural Resources (WDNR) and the U.S. Environmental Protection Agency (EPA) regarding an Alternative Treatment Technique for Reduction of Lead in Drinking Water under Safe Drinking Water Act (SDWA) Section 1415(a)(3).

WHEREAS, WDNR and U.S. EPA are mandated to protect public health from contaminants in drinking water under the Public Water System Supervision (PWSS) Program;

WHEREAS, WDNR has primary enforcement authority for the PWSS Program in Wisconsin;

WHEREAS, U.S. EPA has the authority to issue variances under SDWA Section 1415(a)(3);

WHEREAS, the U.S. EPA Administrator may grant a variance from any treatment technique requirement of a national primary drinking water regulation to a supplier of water, whether or not the public water system for which the variance is requested is located in a State which has primary enforcement responsibility (40 CFR §142.46);

WHEREAS, the authority to issue variances under SDWA Section 1415(a)(3) has been delegated to the Regional Administrators;

WHEREAS, the U.S. EPA has determined that the use of the alternative treatment technique can achieve more efficient and permanent reductions in lead levels than the current treatment technique in the Lead and Copper Rule;

Now, **THEREFORE**, WDNR and U.S. EPA enter into this MOU.

A. Background

The WDNR and U.S. EPA Region 5 are mandated to protect human health and the environment, and acknowledge the need to better integrate implementation of CWA and SDWA provisions to promote sustainability and efficient use of community resources.

In order to protect public health from the harmful effects of lead in drinking water under the SDWA in a manner that will not adversely impact water quality under the CWA, the WDNR and U.S. EPA agree to provide communities in Wisconsin the opportunity to utilize an alternative treatment technique that is at least as efficient as the current LCR for lowering lead in drinking water in systems with LSLs under the SDWA that does not result in adverse impacts on water quality or community compliance with regulatory requirements under the CWA.

B. Purpose

The purpose of this MOU is to set forth the commitments between the WDNR and U.S. EPA Region 5 for implementing and managing the variance designating an alternative treatment technique for the reduction of lead in drinking water for communities in Wisconsin.

The intent of the variance is to make a real difference in communities by increasing the level of protection of human health and the environment utilizing an alternative treatment technique that will be at least as efficient at reducing lead levels in drinking water and more cost-effective over the long-term for many systems as compared to the current Lead and Copper Rule. This effort will also promote the sustainability of communities by reducing or eliminating the use of phosphates at drinking water plants and corresponding discharges of phosphorus into the waters of Wisconsin, and eliminating a disincentive and potential obstacle to water conservation for homes with LSLs. A communications strategy will be developed to ensure effective communication with residents and transparency in government decision-making as directed in Executive Order [xxx] which pertains to all federal agencies.

C. Goals

The main goals established by WDNR and U.S. EPA Region 5 are to:

1. Realize improved human health protection by implementing interim mitigation efforts that are not required by the current LCR;
2. Realize permanent and significant reductions in lead levels by removing all partial and full LSLs, since these are the largest sources of lead in drinking water distribution systems;
3. Provide significant long-term cost reductions for LSL removal by allowing communities to plan and coordinate the removal of LSLs with other infrastructure work to make the most efficient use of limited community resources;
4. Remove barriers to water conservation;
5. Reduce and possibly eliminate the use of phosphates for drinking water treatment; and
6. Promote transparency in the government decision-making process.

D. Authorities and Limitations

The U.S. EPA has delegated primary enforcement authority for the Public Water System Supervision program to the WDNR, and the U.S. EPA Region 5 Office has been delegated the authority to issue variances under the SDWA Section 1415(a)(3) to specify alternative treatment techniques which achieve more efficient contaminant reduction than treatment techniques specified in National Primary Drinking Water Regulations.

Nothing in this MOU shall alter or modify any other compliance requirements under the SDWA or CWA except as allowed and specified in the variance and system agreements. Where unanticipated conflicts between regulatory requirements and the requirements of the variance should arise, the WDNR and U.S. EPA agree to work together to resolve these issues, and to modify the elements of the individual system agreements if necessary to resolve the conflicts in a manner which is consistent with all applicable requirements under the SDWA and CWA and the intent of the variance.

E. Commitments

The WDNR and U.S. EPA Region 5 commit to:

- Appoint a designated contact for implementation of this MOU. The designated individuals will meet at least semi-annually or at the request of either agency to review and discuss implementation of the variance. The WDNR designated contact is [name and/or title], and the EPA designated contact is [name and/or title], or as each designee delegates.
- Implement the variance consistent with U.S. EPA policies and guidance on transparency, sustainability, source water protection, and environmental justice.
- Provide support for, and attend community meetings to inform the residents in communities that elect to utilize the alternative treatment technique.
- Provide ongoing technical assistance to communities that elect to utilize the alternative treatment technique.

F. Additional Commitments by WDNR:

- Establish legally-binding agreements with CWSs in accordance with the required elements in the Community Water System Agreement specified in the Attachment A of the variance.
- Maintain a list of CWSs that have signed agreements.
- Maintain records of all reportable information specified in the CWS Agreements for each participating CWS for a period that is not less than [xx] years following the completion of the removal of all LSLs in the CWS.
- Evaluate CWS compliance with the variance Agreement for each CWS no less frequently than annually.
- Report to EPA, as soon as practicable, but not later than [30] days from learning of any CWS's failure to comply with any agreement requirement(s).
- Require CWSs to undertake corrective actions as necessary to ensure that public health is protected.
- Maintain an information repository with all variance-related documents, including the annual reports, which is readily accessible to the public.
- Provide an annual report to U.S. EPA which contains the summary information listed below for all CWSs that have signed Agreements:
    - [TBD based on final CWS Agreement elements]

G. Additional Commitments by U.S. EPA:

- Develop informational brochure templates for local care providers and residents on the potential risks posed by LSLs.
- Maintain a website with information for residents on how to find LSLs, and steps that residents can take to reduce their lead exposure, including how to find and purchase lead-free plumbing components.
- Provide technical assistance to communities on interim mitigation efforts.

- Provide technical assistance to communities for evaluating the feasibility of reducing or eliminating the use of phosphates for corrosion control and secondary water quality issues. Provide laboratory support for assessing and evaluating sources of lead that will remain in premise plumbing.
- Review annual progress and compliance reports submitted by WDNR.

H. Other Provisions:

This MOU becomes effective upon the final signature of the parties listed below and is to remain in effect for [period of time], after which the parties are to discuss an extension of the MOU for mutual benefit. This MOU may be modified at any time per the mutual consent of the parties and with notice provided to all participating CWSs. Additionally, each party may terminate its participation in this MOU by providing written notice to the other party at least ninety (90) days prior to the desired termination date. In the event that the MOU is terminated by either party, the variance shall also be terminated and CWSs will be required to comply with all applicable provisions of 40 CFR Part 141, Subpart I (Lead and Copper Rule) beginning no later than [xx days] following the termination of this MOU and the associated variance.

Susan Hedman, Regional Administrator
U.S. Environmental Protection Agency

Date

[Name], Secretary
Wisconsin Department of Natural Resources

Date

Potential SDWA/CWA Collaborative on Orthophosphate Reduction vs. Phosphorus Removal
WDNR Office - May 6, 2014

Attendees
EPA – Joe Janczy and Miguel Del Toral
DNR – Steve Elmore and Mark Nelson
Process Control Solutions – Abigail Cantor

Meeting Objective
To discuss a potential collaborative on orthophosphate reduction under SDWA instead of phosphorus removal on the CWA side, and specifically to discuss a project (embedded docs below) proposed by Abigail to the Water Research Foundation (WRF).

[EMBED AcroExch.Document.11][EMBED AcroExch.Document.11][EMBED AcroExch.Document.11][EMBED AcroExch.Document.11]

Executive Summary
DNR and I agree that there is potential here to integrate the SDWA and CWA provisions to avoid the introduction of additional phosphate into the drinking water, but there are significant issues that need to be resolved before I can make a positive recommendation to R5 management on proceeding with support for the WRF project under the authority of a SDWA variance. The issues listed in this meeting summary are not all-inclusive, as discussion focused only on the major issues outlined in these notes, due to time restrictions.

Draft Meeting Summary

The proposal submitted to the WRF is intended to control corrosion primarily by inactivating microbes and maintaining a clean distribution system (proposal embedded). It involves the use of ***Clearitas*** for cleaning the distribution system.

As the WRF proposal had an upcoming deadline, we discussed the issue of a letter of support from DNR and/or EPA first (see attached WRF letter). Essentially what Abigail requested was that we draft a letter in support of the project by May 14. I expressed reservations with recommending such an EPA letter with the proposal as written and informed that we likely could not get that letter out by May 14, even if we were in agreement to do it.

I said I agreed with the concept of trying not to raise orthophosphate dosages, which all parties would like to avoid from a CWA standpoint, but also pointed out that studies consistently show that orthophosphate is the most effective treatment and possibly the only treatment that is capable of reducing lead levels below the Pb AL if we move to LSL sampling, so unless all LSLs are removed or Pb-IV scales can be formed/maintained in the system with confidence, I don't see how we could approve a reduction in the amount of orthophosphate used by systems with LSLs. In the absence of removing the lines or forming and maintaining Pb-IV scales, I would advocate for the opposite - an increase in orthophosphate - to protect the public from the lead levels we are finding, which are considerably higher than LCR compliance monitoring levels.

The premise of the WRF proposal is that the scales contain many contaminants, including microbes that feed on the phosphorus, so control of the scale is desired by utilities, and that Pb-IV scales have a much better chance of being formed when pipes are clean and when microbe concentrations are reduced. We agree on these points and in general that maintaining a clean distribution system is a good thing, but we have different views regarding what is causing/controlling the lead release.

I also mentioned that there is no mechanism within the LCR that would allow a system to reduce their orthophosphate, as systems are required to maintain their OCCT once it is installed, and the only legal mechanism available to do this would be a SDWA 1415(a)(3) variance.

The most significant concerns that that would need to be addressed in any variance were as follows:

1. EPA and DNR stipulated that there must be a public education campaign, including flushing instructions, to inform residents that the proposed flushing (1st stage of project) will stir up high levels of contaminants from within the distribution system. We have seen this cause persistent water quality issues (months) and the public needs to be aware of the potential adverse health issues from it. As Abigail pointed out, systems can do the flushing now without any permission. I agreed with that, but said just because it's not required by a federal rule, does not mean it's something that EPA should ignore when we know there are public health consequences to it and that it should be a variance condition. Steve made this point as well, and we think she understands that this must happen, similar to what they did in Madison.

2. There must be a verifiable inventory of all partial and full LSLs in the system, and instructions must be provided system-wide to residents on how to find out if they have a LSL.

3. We need information on how Clearitas 'slowly cleans' the pipes, as I didn't think EPA could support a project where the vendor will not provide the information we need to assess the potential impacts of the chemical on the LSL scales. She said it was an NSF approved product, but I would want written confirmation from NSF on the approval circumstances and whether NSF was aware of the LSL scale issues when they considered/approved it. It did not seem logical to me that NSF would approve of its use if it strips off the protective scales within LSLs and they knew that.

> Subsequent to the meeting, I have learned that NSF/ANSI 60 certification is only for inadvertent addition of regulated contaminants to the water. It does not certify that the product works for its advertised purpose:

[HYPERLINK "http://www.nsf.org/newsroom_pdf/NSF_60-13_-_watermarked.pdf"]
"NSF/ANSI 60 has been developed to establish minimum requirements for the control of potential adverse human health effects from products added to water for its treatment. It does not attempt to include product performance requirements, which are currently addressed in standards established by such organizations as the American Water Works Association, the American Society for Testing and Materials, and the American National Standards Institute. Because this Standard complements the standards of these organizations, it is recommended that products also meet the appropriate requirements specified in the standards of such organizations."

There is a also footnote about required DBP monitoring in the NSF/ANSI 60 certification listing for Cleartias:

[HYPERLINK "http://info.nsf.org/Certified/PwsChemicals/Listings.asp?Company=0W260&"]

"[1] The Certification of this product has been restricted to a maximum use level (MUL) that is less than the 10 ppm typical use level of chlorine specified for hypochlorite products under NSF/ANSI Standard 60."
"[CL] The residual levels of chlorine (hypochlorite ion and hypochlorous acid), chlorine dioxide, chlorate ion, chloramine and disinfection by-products shall be monitored in the finished drinking water to ensure compliance to all applicable regulations."

In addition to the above footnote, a source which wishes to remain anonymous said they have tested Clearitas and that it contains chlorine dioxide and chlorine, so any system that is currently using it and not monitoring for TTHM, HAA5, chlorine dioxide, and chlorite are in violation of the DBP monitoring requirements. Before proceeding with any enforcement, I would recommend that we have a regional or state lab conduct analysis of the product so that we have the data.

Abigail also asked if i would consider being on the WRF Project Advisory Committee (PAC) for this project, per the WRF letter, and I said I did not have the time unless I could take other stuff off my plate and the above significant issues were addressed.

4. The monitoring in the proposed WRF project is insufficient. One sampling station, along with first-draw sampling or some other protocol that misses the highest lead would not be acceptable as the monitoring under a variance. The DNR agreed and said there must be sampling in the homes, not just at the monitoring stations. I told her that I could not lend support to any project that would use sampling that does not capture the lead, which is what we have seen with 1st draw samples. Abigail pointed out that first-draw samples were what the rule requires and I said they must take sequential samples at the worst-case sites/under worst-case conditions to be protective if we are leaving them

without the protection from orthophosphate. She had cost concerns and I said I would look into potential R5 lab support on the analyses.

5. Another component of the variance I suggested is that they must consider removing all of the lines where it is feasible to do so, as this provides the best assurance that backing off on orthophosphate would not result in lead-poisonings from the drinking water.

Follow-up

•Abigail said she wanted to send us what they will monitor for in terms of water quality parameters, which she has done.

•I will check on the potential for R5 laboratory analytical support for sequential samples.

•DNR will sent a letter to WRF with a 'support in principle' of the concept. DNR will share that letter with EPA once it's drafted.

~~joe - please look this over to make sure I've covered everything.~~

joe and i met with dnr folks (steve elmore and mark nelson) and abigail cantor to discuss the sdwa phosphate/cwa phosphorus issues. It was a cordial exchange with the usual differences of opinion on the same issues i had pointed out before. i think we can resolve them and i there is potential to move forward on a collaborative effort once we do.

abigail's wrf proposal had an upcoming deadline, so we discussed that first (see attached wrf letter). basically, what she wanted initially was a joint epa/dnr letter in support of the project by may 14. i told her as i had indicated to her previously, that i could not recommend such an epa letter with the proposal as written. i told her i agreed with the concept of trying not to raise phosphate dosages, which all parties want to do, but also pointed out that all studies show that orthophosphate is the most effective treatment, and unless all lsls are removed or i am completely convinced that pb-iv scales could be formed/maintained, i don't see how we would approve let a system back off on the orthophosphate, and in the absence of removing the lines or having pb-iv scales, i would advocate for the opposite - an increase in orthophosphate - to protect the public from the lead. abigail's position is that the scales contain many contaminants, including microbes that feed on the phosphorus, so control of the scale is desired by utilities, and that pb-iv scales have a much better chance of being formed when pipes are clean and when microbe concentrations are reduced. we agree on the cleaning and the positive effectives it would have, but we have differences regarding what is causing/controlling the lead release, so not something that we can't deal with.~~she keeps insisting that the cleaning and subsequent scale removal will do the trick, and every other technical person i talk to (regions, mike, marc) have no clue why she still believes this.~~

she also asked if i would consider being on the water research foundation pac for this project, per their letter, and i said i did not have the time and would not be inclined to unless i could take other stuff off my plate and some significant issues were addressed. i also mentioned that the variance would be the only legal mechanism for systems to do what they are suggesting (backing off on orthophosphate) since the rule requires systems to install and maintain the treatment, so systems would be subject to enforcement if they backed off.

the most serious concerns that i told her would have to be addressed in any variance were as follows:

1. there must be a public education campaign, including flushing instructions, to inform residents that the proposed flushing (1st stage of project) will stir up high levels of contaminants from within the distribution system. we have seen this cause persistent water quality issues (months) and the public needs to be aware of the potential adverse health issues from it. her response on this issue was not satisfactory to me - basically, she said they can do this without any epa/state permission. I agreed with that but said just because it's not required by a federal rule, does not mean it's something that epa should ignore when we know there are public health consequences to it and that it should be a variance condition. steve made this point as well, and we think abigail understands that this must happen, similar to what they did in madison.

2. there must be a verifiable inventory of all partial and full lsls in the system, and instructions must be provided system-wide to residents on how to find out if they have a lsl.

3. i told her i don't know how epa can support a project where the vendor of this 'cleaning agent' will not provide the information we need to assess the potential impacts of the chemical on the lsl scales. she said it was nsf approved, but given what we have learned about misleading people on what the products are approved for, I would want written proof that nsf approved this chemical for these circumstances and that nsf was aware of the lsl scale issue when they considered/approved it. It does not seem logical to me that nsf would approve of its use if it strips off the protective scales within lsls and they knew that.

some input from mike on nsf/clearitas:
there are already dozens of systems using this product (and not with the enhanced DBP monitoring that is footnoted in NSF/ANSI 60).

it would also be good to emphasize that NSF/ANSI 60 certification is only for inadvertent addition of regulated contaminants to the water. It has nothing whatsoever to do with whether or not the product works for its advertised purpose. The footnote about DBP monitoring is clear in the NSF/ANSI 60 certification listing.

4. related to 2 above, I said the proposed monitoring is completely insufficient and that one sampling station, along with useless first-sampling or some other protocol that misses the highest lead was a non-starter. The dnr agreed and said there must be sampling in the homes. she (again) pointed out that first-draw samples were what the rule requires. I told her that I would not lend support to any project that could potentially lead-poison the town without anybody knowing it and that is what could happen with 1st draw samples. I said they must take sequential samples at the worst-case sites/under worst-case conditions. she had cost concerns and I said I would look into potential r5 lab support on the analyses.

5. a component of the variance is that they must consider removing all of the lines where it is feasible to do so, as this provides the best assurance that backing off on phosphate would not result in lead-poisoning the town.

follow-up:
•abigail said she wanted to send us what they will monitor for (wqps), which i already have
•i will check on lab support for sequentials
•dnr will sent a letter to wrf with 'support in principle' of the concept. they will share that letter with epa once it's drafted next week.

joe - please look this over to make sure I've covered everything.

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Commented [JJJ1]: I don't remember you saying you couldn't recommend a letter. I recall you saying we couldn't get one through the sign-off chain by May 14.

Commented [JJJ2]: Her first point is that scales contain many contaminants, including microbes that feed on the phosphorus, so control of scale is desired by water utilities and will be pursued. Her second point is that lead IV scales have a much better chance of being formed when the pipes are clean and when microbe concentrations in the pipe are significantly reduced.

she also asked if i would consider being on the water research foundation pac for this project, per their letter, and i said i did not have the time and would not be inclined to unless some significant issues were addressed. i also mentioned that the variance would be the only legal mechanism for systems to do what they are suggesting (backing off on orthophosphate) since the rule requires systems to install and maintain the treatment, so systems would be subject to enforcement if they backed off.

the most serious concerns that i told her would have to be addressed in any variance were as follows:

1. there must be a public education campaign, including flushing instructions, to inform residents that the proposed flushing (1st stage of project) will stir up high levels of contaminants from within the distribution system. we have seen this cause persistent water quality issues (months) and the public needs to be aware of the potential adverse health issues from it. her response on this issue was not satisfactory to me - basically, she said they can do this without any epa/state permission. I agreed with that but said just because it's not required by a federal rule, does not mean it's something that epa should ignore when we know there are public health consequences to it and that it should be a variance condition.

Commented [JJJ3]: I think this was a concern that Steve expressed and I saw Abigail taking notes as Steve spoke, so I think she understands that a Madison-like PE program is a must.

2. there must be a verifiable inventory of all partial and full lsls in the system, and instructions must be provided system-wide to residents on how to find out if they have a lsl.

3. i told her i don't know how epa can support a project where the vendor of this 'cleaning agent' will not provide the information we need to assess the potential impacts of the chemical on the lsl scales. she said it was nsf approved, but given what we have learned about misleading people on what the products are approved for, I would want written proof that nsf approved this chemical for these circumstances and that nsf was aware of the lsl scale issue when they considered/approved it. It does not seem logical to me that nsf would approve of its use if it strips off the protective scales within lsls and they knew that.

Commented [JJJ4]: I have provided you with the information about Clearitas that was presented by the Hawkin's rep to the WDNR at the statewide meeting. You also have Brian Henry's contact information. It really doesn't sound that mysterious. Am I missing something?

Generally speaking, I think these notes project an adversarial tone to the meeting that I really didn't witness. Maybe the two of you at times talked past each other, but for the most part I witnessed a more collegial discussion between two people who knew a lot about corrosion and pipe scales.

4. related to 2 above, I said the proposed monitoring is completely insufficient and that one sampling station, along with useless first-sampling or some other protocol that misses the highest lead was a non-starter. The dnr agreed and said there must be sampling in the homes. she (again) pointed out that first-draw samples were what the rule requires. I told her that I would not lend support to any project that could potentially lead-poison the town without anybody knowing it and that is what could happen with 1st draw samples. I said they must take sequential samples at the worst-case sites/under worst-case conditions. she had cost concerns and I said I would look into potential r5 lab support on the analyses.

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Proposed Sample Schedule for Ponderosa MHP (6047415)

Prepared by Julie M. Floyd, Virginia Dept. of Health, Office of Drinking Water, on July 3, 2013
Updated by Malik Bilal, Future Pyramids, LLC, on July 29, 2013______ (date)

Analyte / Group	Priority	Required Sample Frequency*	Number of Samples Required	Collect By***	Date to be Collected	Comments
Bacteria	1	Monthly	1 from DS**	The 15th of each month	**The 5th of each month**	
Nitrate/Nitrite	1	Quarterly	1 from EP	September 30, 2013 (3rd Qtr) December 31, 2013 (4th Qtr)	**Aug 5, 2013** **Nov 5, 2013**	Collected 7/21/2013
Volatile Organic Contaminants (VOC)	1	Quarterly	1 from EP	September 30, 2013 (3rd Qtr) December 31, 2013 (4th Qtr)	**Aug 5, 2013** **Nov 5, 2013**	Collected 7/21/2013
Lead & Copper	2	Annually	5 from DS	September 30, 2013	**Aug 5, 2013**	
Inorganics (IOC)	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
Metals	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
Radiological (Rads)	3	6 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
Carbamates	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
Herbicides	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
SOC (Semi-Volatile Organic Contaminants)	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	
Fumigants	3	3 years	1 from EP	December 31, 2013	**Nov 5, 2013**	

* Required frequency may change following receipt of sample results. This office will let you know what those changes are.
** DS = Distribution System
EP = Entry Point (tap after storage tank and before the distribution System)
RW = Raw Water (from well before storage tank)
*** It is best to take samples no later than the 15th of the respective month to allow for time for the analysis to be completed and results reported to VDH/ODW. This applies not only to bacteria samples but to all samples in general. Note that the State Lab only accepts bacteria samples Mon-Thurs and will have additional limitations around holidays. There are free courier sites around the state where you can drop off samples for transport to the State Lab rather than having to ship or drive them to the Lab.

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Updated by Malik Bilal, Future Pyramids, LLC, on July 29, 2013______ (date)
Chart updated on 11/13/13 by Julie M. Floyd, Office of Drinking Water

Analyte / Group	Priority	Required Sample Frequency*	Number of Samples Required	Collect By***	Collected	Comments
Bacteria	1	Monthly	1 from DS**	The 15th of each month	**7/21/13, 8/21/13, 9/8/13, 10/3/13**	Monthly Sampling began July 2013
Nitrate/Nitrite	1	Quarterly	1 from EP	September 30, 2013 (3rd Qtr) December 31, 2013 (4th Qtr)	**Collected 7/21/13, Q4 sample in-process at lab**	Q3-2013 = 0.09 mg/L
Volatile Organic Contaminants (VOC)	1	Quarterly	1 from EP	September 30, 2013 (3rd Qtr) December 31, 2013 (4th Qtr)	**Collected 7/21/13, Q4 sample in-process at lab**	Q3-2013 No Primary Contaminants detected
Lead & Copper	2	Annually	5 from DS	September 30, 2013	**Collected 8/24-8/25**	2013 90th Pb= 0.0023 mg/L;90th Cu = 0.10 mg/L; none>AL
Inorganics (IOC)	3	3 years	1 from EP	December 31, 2013	**Q4-2013: Sample in-process at lab**	
Metals	3	3 years	1 from EP	December 31, 2013	**Q4-2013: Sample in-process at lab**	
Radiological (Rads)	3	6 years	1 from EP	December 31, 2013	**Q4-2013: Sample in-process at lab**	
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COMMONWEALTH of VIRGINIA

Karen Remley, MD, MBA, FAAP
State Health Commissioner

J. Wesley Kleene, PhD, PE
Director, Office of Drinking Water

DEPARTMENT OF HEALTH

OFFICE OF DRINKING WATER

Lexington Field Office

131 Walker Street
Lexington, VA 24450
Phone: 540-463-7136
Fax: 540-463-3892

Groundwater System Sanitary Survey Report

October 4, 2011

To: Mr. David Matthews
P.O. Box 26
Luray, Virginia 22835

Subject: Page County
Water – Shenandoah Utility Services
PWSID No. 2139017

Inspection Date: 10/ 03 //2011

Inspection Type: Routine

Present at Inspection: Mr. David Matthews

Next Inspection Scheduled For: 10/2012

Future Sampling Requirements:

Next Sample Date	Inorganics	Metals	Radiological	VOCC	
	Past Due	Past Due	Past Due	Past Due	
Next Sample Date	Lead/Copper	Nitrates	Cyanide	TTHM	HAA5
	06/2012	Past Due	Past Due	08/2013	08/2013

As a result of the sanitary survey noted above, the Department offers the following comments. Should you have questions or desire to discuss our findings, or desire a copy of the inspector's field evaluation notes, please contact us at 540-463-7136. Tom Eberly, District Engineer, can be reached at extension 108, Chuck Conner, Assistant District Engineer, at extension 110, and the undersigned at extension 109.

- Overall, the system appeared to be maintained and functioning satisfactorily.

- During the time of inspection, the following areas of concern were noted and need to be addressed. Please note that all these items are ones that have been reported on previous inspection reports and you have continued to not meet these requests. Since you have been operating the system, 161 Notices of Violation have been sent to you from our office. In addition, EPA has issued an Administrative Order because of persistent violations. I feel that it is in your best interest that you work diligently toward bringing your water system back into compliance.

1. Since you purchased the system, only two monthly operational reports have been received and they were for July and September 2009; however, the information given was incomplete. Monthly reports need to be sent to the Lexington Field Office by the 10th of each month; and they are to include water usage, daily chlorine residuals, number of connections, population served, and any pertinent comments relating to the daily operation. The "NOTES" column should include amounts and types of chlorine compounds added, maintenance records, equipment replacement, comments,

VIRGINIA DEPARTMENT OF HEALTH
OFFICE OF DRINKING WATER
GROUNDWATER SYSTEM SANITARY SURVEY REPORT

Water - Shenandoah Utility Services

Comments: (continued)

etc. for the system. Please begin sending monthly operational reports with all the requested data by November 10, 2011.

2. On July 15, 2007, Mr. Pierce resigned as the licensed operator for your water system; at that time, you stated that you plan to take the exam to obtain your Class VI license. To date, you have not taken the exam nor have you hired a Class VI or higher licensed operator for your water system. You need to hire a licensed operator for your system.

3. The opening where the float switch enters the temporary storage tank needs to be sealed with caulk.

4. The site glass on the water meter needs to be replaced or a new meter installed because the meter is not readable and you need to be taking monthly meter readings to send to the Lexington Field Office.

5. The electrical switch for the lights in the well house needs to be installed properly; two wires should not be touched together to make the lights come on.

6. The water system needs to have a spare chlorine feeder for the disinfection system.

7. The 15-gallon chlorine solution tank was replaced with a 5-gallon empty dry-wall bucket; a new unused plastic solution tank needs to be purchased to replace the used dry-wall bucket.

8. The Inorganic, Metals, Radiological, VOCC, Cyanide, and Nitrate + Nitrite samples are past due for your water system. Please collect these samples.

Please visit our web site at www.vdh.virginia.gov/drinkingwater. There you will find helpful information on water sampling and testing, operator licensing and training, consumer education, project funding and many other topics, as well as, links to other key websites and Virginia's *Waterworks Regulations*.

Survey By:

Linda C. Irby

Linda C. Irby
Environmental Inspector

cc: VDH-ODW-Central Office
Page County Health Department,
Page County Administrator, Mark Belton

VIRGINIA DEPARTMENT OF HEALTH
OFFICE OF DRINKING WATER
GROUNDWATER SYSTEM SANITARY SURVEY REPORT

SUBJECT: **Page County**
WATERWORKS: **Shenandoah Utility Services**
PWSID: **2139017**

PART I - SYSTEM BACKGROUND
GENERAL INFORMATION

Owner Name: David Matthews	Waterworks Class: VI
Type of Waterworks: Community	
Contact Name: David Matthews	
Contact Address: P.O. Box 26, Luray, Virginia 22835	
Contact Phone Number: 540-743-5006	

D.O. License Class:	D.O. Has Required License: No
D.O. Legal Name:	License No./Exp. Date:

Inspection By: Linda Irby	Inspection Date: 10/ 03 /2011
Time Spent: 1.0 hours	Last Inspection Date: 10/04/2010
Date to Reviewer: 10/ 04/2011	Reviewed by/Date: 10/11/2011 [illegible]
Date to Reviewer:	Reviewed by/Date:
Inspection Type: Routine	
Present at Inspection: David Matthews	
Facilities Inspected: Well, Chlorination, and Storage Facilities	

Operation Permit Effective Date: 08/12/2004	Engineering Description Sheet Date: 08/12/2004
Permit Up-to-Date: Yes	Description Sheet Up-to-Date: Yes
No. Connections: 18	Population Served: 55
Avg. Daily Production: ①	Operation Permit Capacity: 18 Existing Connections
Exceeds 80% Operation Permit Capacity? (max. 3 consecutive months): ① If yes, explain:	
Treatment Provided: Chlorination	
SDWIS Inventory Information Current: Yes	
Comments: ① To date no complete monthly operational reports have been received	

COMPLIANCE HISTORY

Shaded Boxes	Indicate a potential Significant Deficiency

TOTAL COLIFORM & GROUNDWATER RULE		DATE
• BSSR Approved:	Y	06/25/2004
• TSWMP Approved:	N	
• Are plans current & appropriate for service population?	Y	
• Sampled in accordance with approved plans?	Y	
• Disinfection required? (adequate contact time)	Y (unknown)	
Source # / Name (if multiple sources, list)		
• 4-Log virus inactivation required?	N	
Source # / Name (if multiple sources, list)		
• 4-Log virus inactivation provided?	N	
Source # / Name (if multiple sources, list)		
• On-line chlorine analyzers required for chlorine residual?	N	
ROUTINE RAW WATER BACTERIOLOGICAL MONITORING (***checked over past 12 months***)		
• Required?	Y	
○ If "Yes", Frequency:	Quarterly	
• # of *E. coli* positive Samples	①	
• # Samples with Total Coliform >100 CFU/ml	①	
GUDI DETERMINATION	**RESULT**	**DATE**
• *Source # / Name* Well 1	Not UDISW	06/21/1994
SOURCE WATER ASSESSMENT PERFORMED		
• *Source # / Name* Well 1	Karsts Topography	09/19/2002
SOURCE WATER PROTECTION		
• Written source water protection plan?	Y	
DDBP RULE - STAGE 1 (Community & NTNC, Disinfectant Used)		**DATE**
• Stage 1 Monitoring Plan approved?	Y	05/19/2006
• Monitoring Plan current?	Y	
• Monitoring frequency required:	Every 3 years.	
DDBP RULE - STAGE 2 (Community & NTNC, Disinfectant Used)		**DATE**
• Stage 2 Sampling Plan approved and current?	VSS Waiver	12/14/2006
• Compliance Extension Requested?	NA	
○ If "Yes", granted?		
○ If "Yes", effective exemption dates:		
Comments: ① No quarterly samples collected for 2011; the last MPN sample was collected on 08/31/2010.		

Y = Yes; N = No; NA = Not Applicable; N/I = Not Inspected; None = None; OK = Acceptable

PHASE II/V RULE		
• Waivers current for <u>all</u> entry points	Y	
CONSUMER CONFIDENCE REPORTS (Community only)		
• Final report issued by deadline	N	
• Certification Statement Received?	N	
LEAD & COPPER RULE (Community & NTNC)		**DATE**
• Materials Survey/Sampling Plan Approved:	Y	06/03/1999
• Action Level Exceedance (90%)	N	
• Optimized Corrosion Control Treatment (OCCT) required?	N	
• Public Education requirements met if required	Y	
• All consumer notice requirements met?	Y	
CROSS-CONNECTION CONTROL PROGRAM		**DATE**
• Approved:	Y	08/02/1985
• Inspected Records This Visit	N	
o Program Active	Y	
o Satisfactory	Y	
(MONTHLY) OPERATION REPORTS		
• All submitted for past 12 months?	N	
• Operational treatment parameters monitored?	N	
• All required data reported?	N	
EMERGENCY MGMT. PLAN for Extended Power Outage (Community only)		**DATE**
• Verification received?	N	
• Current?	N	
ASSET MANAGEMENT (recommendation)		
• Written Plan Developed?	N	
• Routine Maintenance Performed?	Y	
ENFORCEMENT		**DATE**
• Administrative/Consent Order in Effect:	EPA Admin.	7/27/2009
• Violations / Enforcement Actions Since Last Survey:	Y 80 Violations	
• Owner issued Public Notice as required?	②	
• Active Corrective Action Plan?	Y by EPA	
o If "Yes", is waterworks on schedule?	N	
• SDWIS Violation & Enforcement Action, Public Notification data current?	Y	
COMPLAINTS SINCE LAST INSPECTION: NONE		
• If yes, summarize:		
Comments: ① To date no complete monthly operational reports have been received ② Public notices were issued after 61 violations were sent for failure to issue them		

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Chemical Schedule for 2139017 SHENANDOAH UTILITY SERVICES

SS004 EP - WELL 1 TMT PLT

EP001 TAP AFTER CL2-WELL 1

Group	Last Sample	Freq.	Next Sample	Waiver Exp. Date	Comments
SOCs - Carbamates		0		12/31/2013	
SOCs - Chlorinated Acidic Herbicides		0		12/31/2013	
SOCs - Diquat		0		12/31/2013	
SOCs - Semi-Volatile Organic Chemical		0		12/31/2013	
SOCs - Volatile Fumigants		0		12/31/2013	
Nitrate + Nitrite (Combined)	9/28/2006	12	9/28/2007		FTS NOVs for 2004
VOC	10/31/2006	12	10/31/2007		
Cyanide	4/19/1999	108	4/1/2008	12/31/2019	
Inorganics	10/25/2005	36	10/25/2008		
Metals	10/25/2005	36	10/25/2008		
Radiological	8/31/2010	3	11/30/2010		

DS950 SHENANDOAH UTILITY SERVICES

DS002 244 AIRSTRIP

Group	Last Sample	Freq.	Next Sample	Waiver Exp. Date	Comments
HAA5	8/31/2010	36	8/31/2013		Not sampled 2007, 2008, 2009
TTHM	8/31/2010	36	8/31/2013		Not sampled 2007, 2008, 2009

5 Lead and Copper Samples due 6/1/2012

A. SOURCES	W1
Sanitary Casing Seal /Cap	OK
Elbowed Casing Vent/Screened	Y
12" Casing Extension	Y
Concrete Pad (6' Square)	Y
Well Lot Condition (50 ft Radius)	Y
Protected from Flood Waters/ Runoff	Y
Discharge Check Valve	Y
Discharge Shut-Off Valve	Y
Valved Blow-Off	Y
Raw Water Sample Tap	Y
Water Level Gauge or Transducer	N
Operable Water Meter/Reading	①
Permitted Capacity (gpm)	35
Pumping Rate Observed (gpm)	①
Pumping Average hrs/day	Not Monitored
Permitted Source Capacity Exceeded?	No Monthly Reports
Discharge Head Observed (psi)	NA
All Weather Access	Y

B. TREATMENT BUILDING / VALT	
Adequate Protection	②
Proper Storage Only (Non-toxic & Non-explosive)	Y
Cross-Connections Exist?	N
Lighting	Y
Heating	N
Electrical Wiring (Safety)	Y
Floor Drain	Sump pump
All-Weather Access	Y
Wellhead Accessible	NA
Locked	Y
Clean/Uncluttered	Y
Emergency Power Available	Y

Comments:

① The site glass on the water meter needs to be replaced or a new meter installed; the meter is not readable.
② The holes in the wooden siding and roof of the Treatment Building / Vault need to be repaired.

C. FOUR 86-GALLON PRESSURE TANKS	
Type: Pre-Pressurized or Hydro-Pneumatic	Pre-Press
Drain Protected from Contamination	NA
Pressure Gauge/Reading	46
Pressure Operating Range	30/50
Sight Glass/ Level Indicator	NA
Sample Tap Available	NA
Pressurizing System	OK
Vacuum Relief Valve	NA
Pressure Relief Valve	Y
Air Relief Valve	NA
Exterior Condition	OK
Normal Pump Cycling	Y
Tank Watertight, Structurally Sound	Y
Flushed/Cleaned Date	NA
Dept. of Labor & Industry Exp. Date (>120 gal.)	NA

D. CHEM. FEED SYSTEMS SAFETY / GENERAL	
Do any chemical storage and handling facilities offer potential for explosions?	N
Is adequate safety equipment provided for chemical handling (i.e. rubber gloves, breathing apparatus, goggle, aprons, etc.)?	Y
Are Material Data Safety Sheets (MSDS) available?	N
Are hazardous chemical containers labeled?	Y
Is adequate chemical storage area provided?	Y
Are there approved backflow prevention devices installed to isolate process water from finished water?	Y
Does the waterworks have adequate employee safety training?	Y

E. DISINFECTION	
Disinfectant	OCl
ANSI Certified/NSF Approved / "GRAS"	Y
Feeder Condition	OK
Spare Feeder/Repair Parts	N ③
Room Ventilation	NA
Contact Tank in service	N
Contact Tank Condition	NA
Injection Line Condition (Scale Build-Up, etc.)	OK
Solution Tank Condition	④
Solution Tank Covered	Y
Feeder Activation/Operation	With well pump
Weight (gas) or Volume/ Depth (OCl) Scale	NA
Number Full Cylinders (Gas Only)	NA
Booster Pump(s)	NA
Residual Test Equipment	DPD
Free Residual, mg/l	2.0
Field test ≈ MOR residuals	No Monthly Reports Sent

F. NEW ACTIVITIES OR POLLUTION SOURCES
within 1000 ft radius of well that present a significant/acute health risk.

Activity or Pollution Source	Approx. Distance from Well
None	

Comments Continued:

③ System needs to have a spare feeder.
④ The 15-gallon solution tank was replaced with a 5-gallon empty dry wall bucket, a new unused plastic solution tank needs to be purchased to replace the dry-wall bucket.

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G. TEMPORARY STORAGE TANK (2007) 800-Gallons	
WATER QUALITY PROTECTION	
Structure Watertight	Y
Vent Shielded and Screened	Y
Drain Satisfactory, Protected	NA
Tank Overflow	
• Screened	Y
• Air Gap Provided at Outlet	Y
• Splash Pad/Erosion Protection	N
Roof Hatch Watertight	Y
Sidewall Access Watertight	Y
Accesses Locked/Bolted	Y
Other Tank Openings Curbed and Sleeved	NA
Other Tank Openings Covered	NA
Maintenance/Repair Date	2007
Frequency/Date of Professional Tank Survey (Recommended ~5 yr)	None
Frequency/Date of Routine Tank Survey (Recommended ~1yr)	Weekly
Tank(s) Appear Structurally Sound	Y
Properly Modified for Antennae?	NA
WATER QUALITY MAINTENANCE	
Sample Tap Available	N
Frequency Samples Collected	NA
Floating Debris Observed	Could not observe
Good Turnover Potential	Y
Flushed/Cleaned Date	08/2010
OPERATION	
Tank Level Controls Operable	Float Switch
Automatic or Manual	Auto
Tank Level Recorded	N
Automatic Recorder Operable	NA
CORROSION CONTROL	
Routine Interior Inspections Scheduled	N
Interior Corrosion Visible	Could not observe
Exterior Corrosion Visible	N
Cathodic Protection Operable	NA
SAFETY	
Interior/Exterior Ladder Condition	NA
Interior/Exterior Ladder Guard	NA
Adequate Railing Available	NA
Safety Belt Available	NA
LOT	
Upkeep	OK
Access Road Maintained	Y
Surface Water Diverted	Y
Fence Condition Good	NA
Access Locked	N

H. BOOSTER PUMP STATION(S) (NAME/LOCATION)	
PUMP STATION LOT	
Upkeep Adequate	Y
Surface Water Diverted Away	Y
Access Road Maintained	Y
PUMP STATION BUILDING	
Light Operable	Y
Ventilation Operable	NA
Heating Operable	N
Pump Gland Piped to Drain	N
Concrete Floor	Y
Screened Floor Drain	Sump pump
Locked	Y
Deterioration &/or Damage Evident	①
Storage of Toxic Chemicals	N
PUMP STATION OPERATIONS	
No. of Pumps in Operation	1
All Pumps Operable	Y
Pump Controls:	
• Automatic	Y
• Manual	
Pump Alternation:	NA
• Automatic	
• Manual	
Flow Meter Operable	N
Low Pressure Cut-off	30 PSI
Alarm Operable	NA
Compound Gauges Operable	Y
Cross Connections are Present	N
PUMP MAINTENANCE	
Pump Service Schedule	N
Pump Service Recorded	N
Discharge Gate Valve	Y
Suction Gate Valve	Y
Check Valve	Y
Emergency Power Available	Y

COMMENTS:

① The holes in the wooden siding and roof of the Treatment Building / Vault need to be repaired.

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G. DISTRIBUTION SYSTEM EVALUATION

Pipe Material(s): PVC	
Individual Service Meters provided?	Plans are to install meters at each residence; presently 6 meters are installed.
○ If yes, routine calibration & replacement program in effect?	N
Flushing Provisions (hydrants, blow-offs, etc.) available?	N
Routine Flushing Program in practice?	Y
○ If yes, describe: Residences are flushed after repairs.	
Isolation valves exercised?	Y
○ If yes, describe: Valves exercised annually	
Air/vacuum relief valves checked for operability?	NA
○ If yes, describe:	
Pressure monitoring of distribution system?	Y
○ If yes, describe: Check at residences	
Adequate Pressure Maintained Throughout? (>20 psi @ peak flow)	Y
Problems/Complaints in past year: NONE ☐taste & odor ☐pressure ☐turbidity/sediment ☐color ☐service interruptions ☐other Describe:	
Pipe Repair - proper disinfection/sampling procedures used?	Y
Re-chlorination practiced? (If yes, see separate Re-Chlorination table in this report.)	Tablet Method
FIRE PROTECTION PROVIDED?	N
How often are Fire Flow Tests conducted (with fire dept.)?	NA
How often are hydrants checked for operability?	NA
Are fire hydrants "NFPA-coded" to indicate maximum available fire flow?	NA
○ If yes, is operator familiar with fire hydrant "code"?	NA
Are operators familiar with tank levels necessary to provide target fire flow for target duration?	NA
Does waterworks have routine procedures for contacting local fire department(s) to verify available fire flow and duration?	NA
MANAGEMENT	
Plans/Sketches/Maps with valve & master meter locations?	Y
Records maintained (should be kept for 3 years minimum): ☑Repairs ☑Flushing ☐Hydrant Testing ☐Fire Flow Tests ☐Water Audits ☑Complaints	
How often are Water Audits conducted?	Presently meters are not read; a flat rate is charged for each residence.
Leakage rates > 30%? Explain:	N
Comments: *(Include information on water accountability).*	

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SHENANDOAH UTILITY SERVICES
P.O. Box 26, Luray, Virginia 22835
PAGE COUNTY – PWSID 2139017

Report Date: April 2013

A) CHLORINE RESIDUAL READINGS

DATE	LOCATION	RESIDUAL	NOTES **
1	Hick	.2	
2	Alger	2	
3			
4			
5	Hig	2	
6			
7			
8	Hick	2	
9			
10	Alger	2	
11			
12	Miller	2	
13	Purdham	2	
14			
15			
16	Hick	2	Clean Pump House
17			
18			Insp 9:30
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

** Notes include amounts and types of chlorine compounds added, maintenance records, equipment replacement, etc. for system.

B) WELL YIELD REPORTS

This month's meter reading__________

Last month's meter reading__________

Total month's usage (Gals)__________

C) WATER SYSTEM

Number of Connections: 20 Population: ______

Please submit this report before the 10th day of the following month to the address below:

VDH/OFFICE OF DRINKING WATER
Lexington Environmental Engineering Field Office
131 Walker Street
Lexington, Virginia 24450-2431

☐ If more forms are needed, please check this block. Signature__________